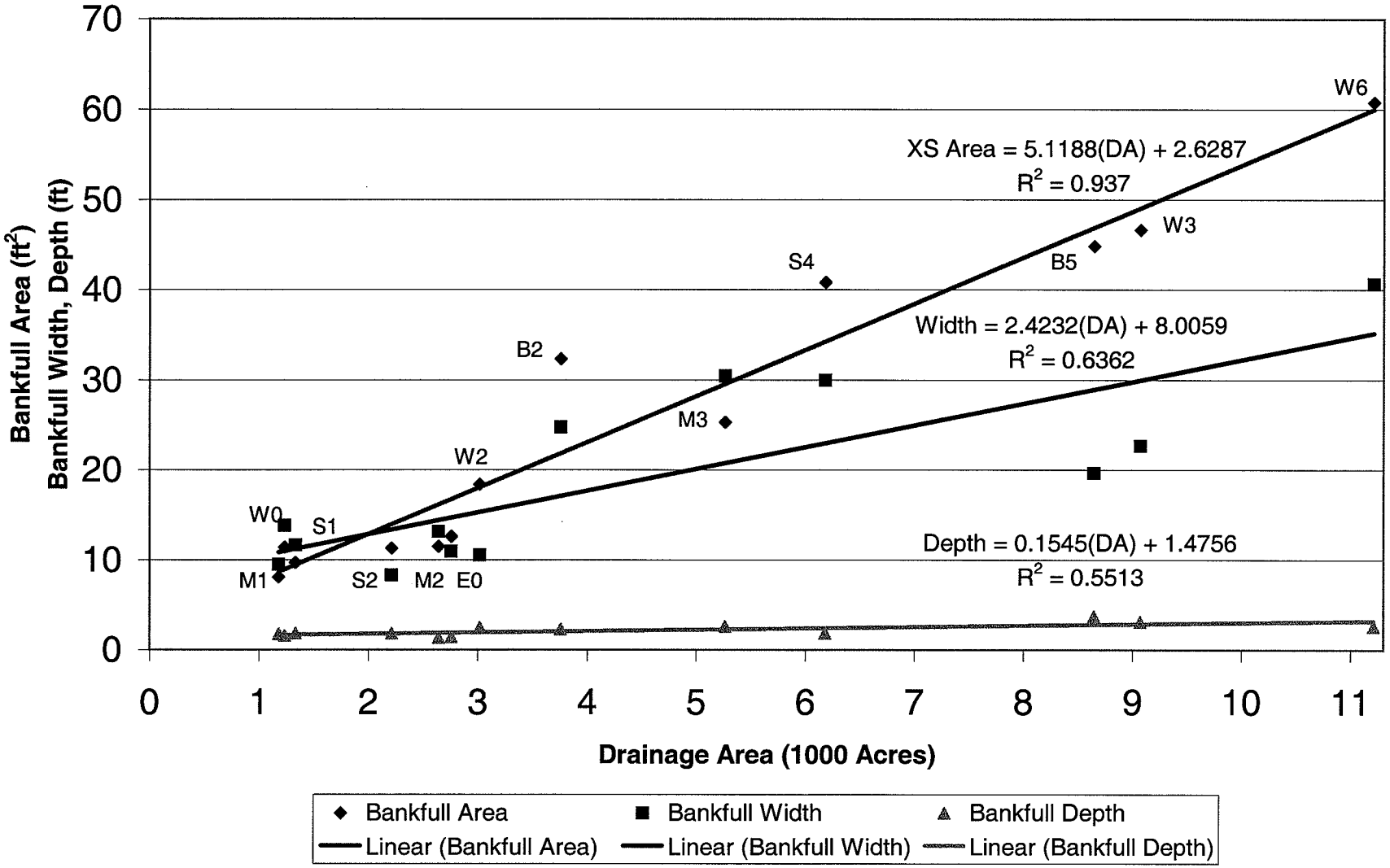
Appendix 1: Regional Curve Data

Anchor Bay Watershed - Regional Curves



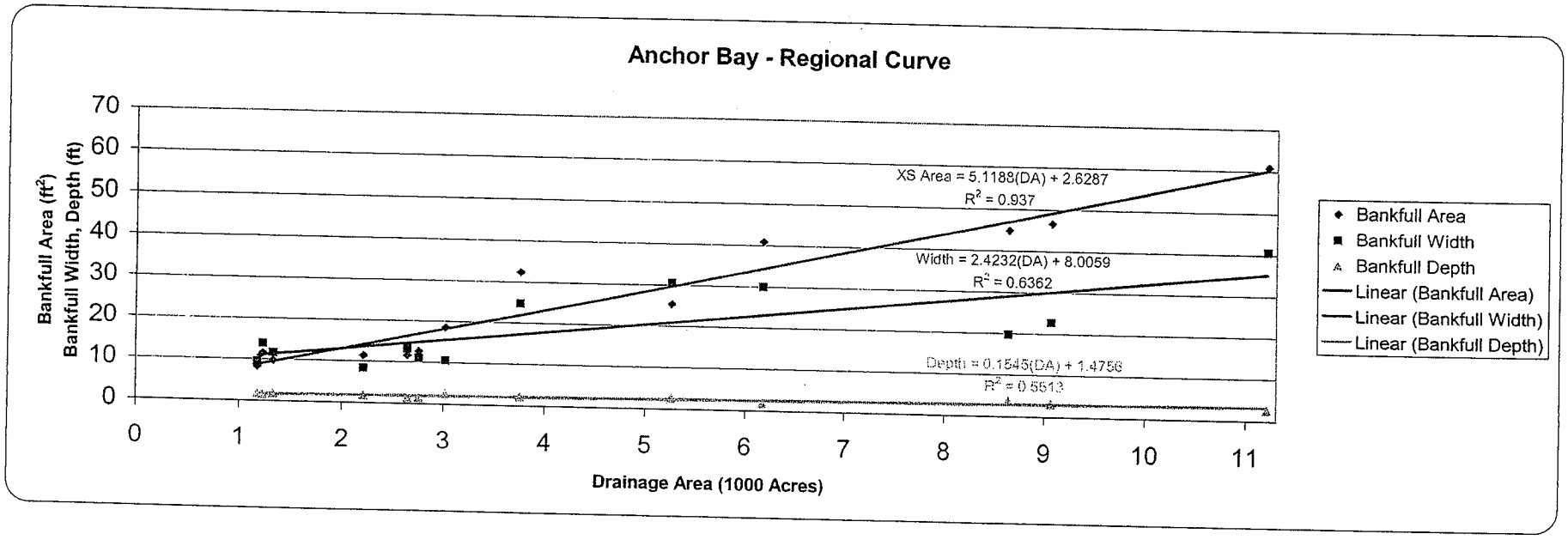
Project: Anchor Bay Watershed
No: G04211
Survey Date: 3/3/2005
Engineer: DF2

Template Title: Anchor Bay - Regional Curve

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Regional Curve Data

Reference Reach ID	Drainage Area (1000 Acres)	Bankfull Flow Area (ft^2)	Bankfull Width (ft)	Bankfull Depth (ft)	Bankfull Discharge (CFS)	Bankfull Frequency (Years)	Soil Symbol	Soil Name	Unified Soil Classification	Dominate USDA Texture Soil Description
M1	1.179	8.1	9.46	1.75	10.12		LhA	Latty Complex	ML-CL, CH	Silty Clay Loam, Clay
W0	1.232	11.4	13.79	1.57	17	0.9	LhA	Latty Complex	ML-CL, CH	Silty Clay Loam, Clay
S1	1.334	9.7	11.63	1.84	8.56	0.6	Hy	Hoytville Clay Loam	CH, CL, MH	Silty Clay Loam, Clay
S2	2.212	11.3	8.29	1.81	25.59	0.7	Sh	Shoals Loam	CL, ML, CL-ML	Loam, Silty Loam
M2	2.643	11.5	13.13	1.32	20.48	0.6	LhA	Latty Complex	ML-CL, CH	Silty Clay Loam, Clay
E0	2.758	12.6	10.91	1.42	32.14	1.6	LhA	Latty Complex	ML-CL, CH	Silty Clay Loam, Clay
W2	3.018	18.4	10.5	2.47	13.62	0.6	LhA	Latty Complex	ML-CL, CH	Silty Clay Loam, Clay
B2	3.756	32.3	24.76	2.27	102.77	0.9	Le	Latty Silty Clay Loam	ML-CL, CH	Silty Clay Loam, Clay
M3	5.264	25.3	30.45	2.59	56.11	0.8	AtA	Allendale-Lenawee-Toledo Complex	SM, SP-SM, CH	Loamy Fine Sand, Fine Sand, Clay
S4	6.178	40.8	29.97	1.84	23.25	0.6	Sc	Saranac Clay Loam	CL, CH, SM, SP-SM	Clay, Silty Clay
B5	8.643	44.8	19.65	3.69	142.32	0.8	To	Toledo Silty Clay Loam	CL, CH, SM	Silty Clay Loam, Clay, Clay Loam, Fine Sandy Loam
W3	9.068	46.6	22.68	3.08	52.36	0.8	Au	Alluvial Land		Stratified Mineral Material of Sand to Silty Clay Texture
W6	11.21	60.8	40.6	2.57	19.3	0.7	Au	Alluvial Land		Stratified Mineral Material of Sand to Silty Clay Texture



Appendix 2: Reference Reach Cross Sections

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: JMH *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Beaubien Creek (B2) - Downstream of Arnold Road

Benchmark: 100 Bolt on Top of South End (Outlet) of Culvert

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
	5.97	105.97			
					186' Downstream of Culvert
0			8.85	97.12	Left Bankfull
0			11.10	94.87	Channel Bottom
0			10.47	95.50	Water Surface
0			8.44	97.53	Right Bankfull
					236' Downstream of Culvert
50			9.12	96.85	Left Bankfull
50			10.98	94.99	Channel Bottom
50			10.50	95.47	Water Surface
50			9.54	96.43	Right Bankfull
					286' Downstream of Culvert
100			9.30	96.67	Left Bankfull
100			11.08	94.89	Channel Bottom
100			10.68	95.29	Water Surface
100			9.34	96.63	Right Bankfull
			4.23	101.74	Turning Point
	6.54	108.28			Re-Set
					336' Downstream of Culvert
150			11.54	96.74	Left Bankfull
150			13.67	94.61	Channel Bottom
150			13.04	95.24	Water Surface
150			11.67	96.61	Right Bankfull
					386' Downstream of Culvert
200			12.05	96.23	Left Bankfull
200			13.73	94.55	Channel Bottom
200			13.07	95.21	Water Surface
200			11.14	97.14	Right Bankfull
					436' Downstream of Culvert
250			11.35	96.93	Left Bankfull
250			13.53	94.75	Channel Bottom
250			13.05	95.23	Water Surface
250			11.55	96.73	Right Bankfull
					486' Downstream of Culvert
300			11.33	96.95	Left Bankfull

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: JMH *Spreadsheet Computed by DF2*

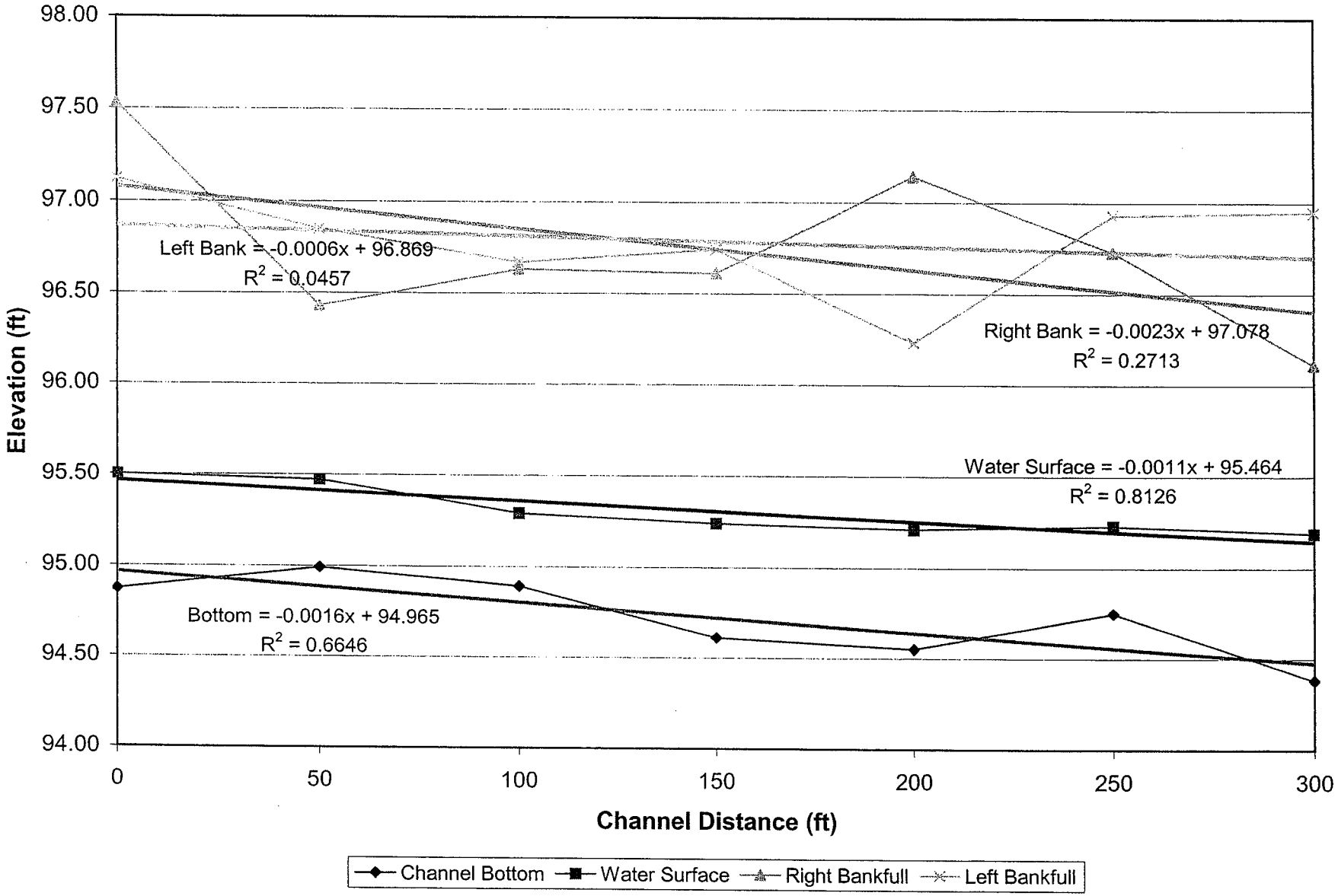
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Beaubien Creek (B2) - Downstream of Arnold Road

Benchmark: 100 Bolt on Top of South End (Outlet) of Culvert

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
300			13.90	94.38	Channel Bottom
300			13.09	95.19	Water Surface
300			12.17	96.11	Right Bankfull
BAD DATA			6.12	99.85	Turning Point
	3.83	103.68			Re-Set
					536' Downstream of Culvert
350			9.32	94.36	Left Bankfull
350			11.31	92.37	Channel Bottom
350			10.77	92.91	Water Surface
350			9.64	94.04	Right Bankfull
					End of Survey
400			9.60	94.08	Left Bankfull
400			11.19	92.49	Channel Bottom
400			10.83	92.85	Water Surface
400			9.32	94.36	Right Bankfull

Beaubien Creek (B2) - Reference Reach Profile



Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: JMH *Spreadsheet Computed by DF2*

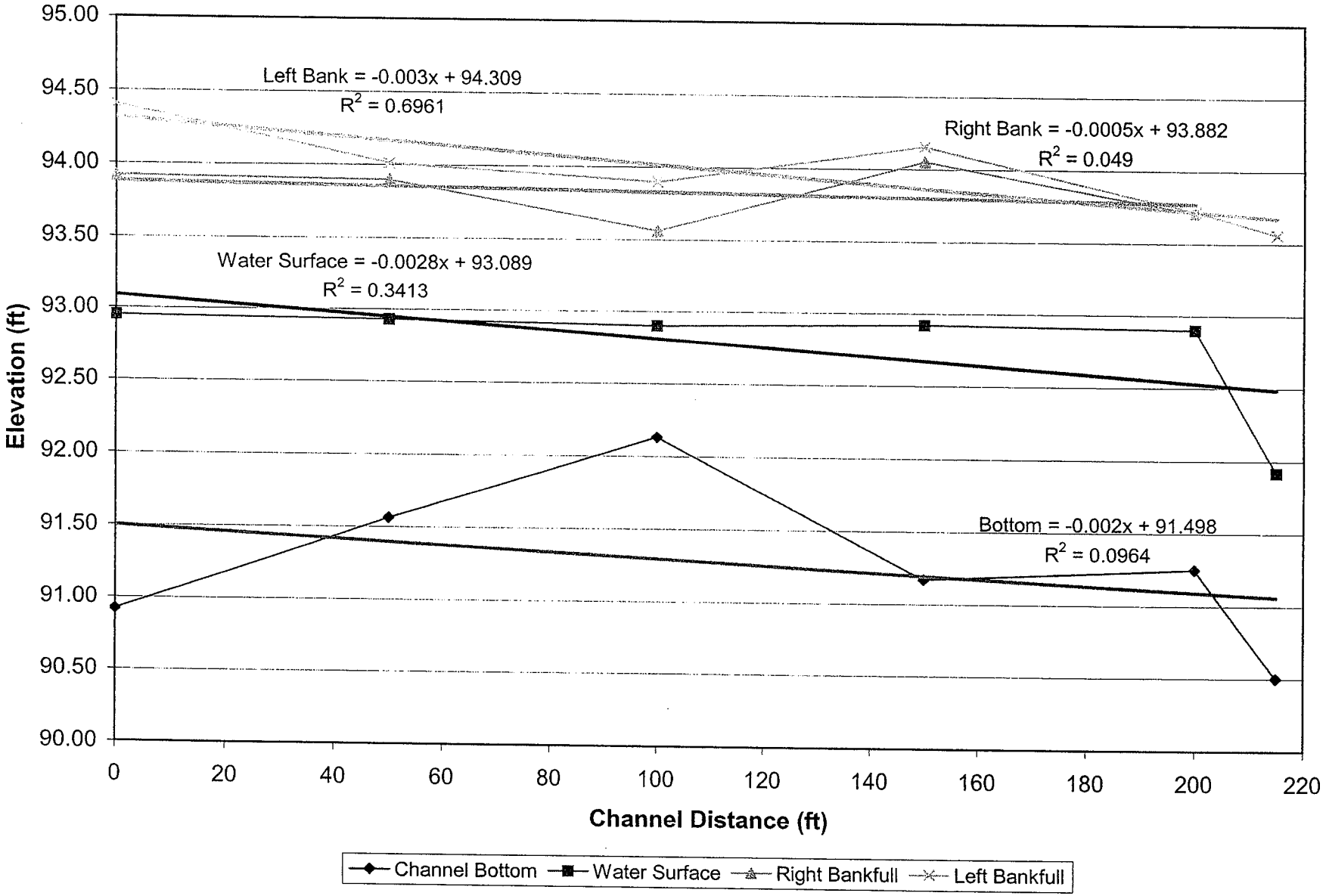
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Beaubien Creek (B5) - Downstream of Starville Road

Benchmark: 100 SW Corner of Bridge Abutment

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
	3.38	103.38			
					51' Downstream of Bridge
0			8.98	94.40	Left Bankfull
0			12.46	90.92	Channel Bottom
0			10.43	92.95	Water Surface
0			9.46	93.92	Right Bankfull
					101' Downstream of Bridge
50			9.37	94.01	Left Bankfull
50			11.82	91.56	Channel Bottom
50			10.45	92.93	Water Surface
50			9.48	93.90	Right Bankfull
					151' Downstream of Bridge
100			9.48	93.90	Left Bankfull
100			11.25	92.13	Channel Bottom
100			10.48	92.90	Water Surface
100			9.82	93.56	Right Bankfull
					201' Downstream of Bridge
150			9.23	94.15	Left Bankfull
150			12.21	91.17	Channel Bottom
150			10.46	92.92	Water Surface
150			9.33	94.05	Right Bankfull
			3.38	100.00	Turning Point
	2.06	102.06			Re-Set
					251' Downstream of Bridge
200			8.34	93.72	Left Bankfull
200			10.81	91.25	Channel Bottom
200			9.16	92.90	Water Surface
200			8.35	93.71	Right Bankfull
					End of Survey
215			8.50	93.56	Left Bankfull
215			11.56	90.50	Channel Bottom
215			10.14	91.92	Water Surface
215			NA	NA	Right Bankfull

Beaubien Creek (B5) - Reference Reach Profile



Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: JWF *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M1) - Downstream of Springborn Road

Benchmark: 97.45 PK Nail in S. UTPL North of Road, East of Culvert

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
	2.55	100.00	4.70	95.30	Turning Point
	4.56	99.86			
					53' Downstream of Culvert
0			8.05	91.95	Left Bankfull
0			10.70	89.16	Channel Bottom
0			9.66	90.20	Water Surface
0			8.70	91.16	Right Bankfull
					Pool
10			8.60	91.26	Left Bankfull
10			10.27	89.59	Channel Bottom
10			9.66	90.20	Water Surface
10			8.52	91.34	Right Bankfull
					103' Downstream of Culvert
50			8.40	91.46	Left Bankfull
50			10.75	89.11	Channel Bottom
50			9.65	90.21	Water Surface
50			8.45	91.41	Right Bankfull
			4.23	95.63	Turning Point
	4.45	100.08			
					Riffle
63			8.75	91.33	Left Bankfull
63			10.10	89.98	Channel Bottom
63			9.90	90.18	Water Surface
63			8.51	91.57	Right Bankfull
					153' Downstream of Culvert
100			9.00	91.08	Left Bankfull
100			10.15	89.93	Channel Bottom
100			9.95	90.13	Water Surface
100			8.98	91.10	Right Bankfull
					203' Downstream of Culvert
150			9.02	91.06	Left Bankfull
150			10.28	89.80	Channel Bottom
150			9.98	90.10	Water Surface
150			8.99	91.09	Right Bankfull
					End of Survey
165			8.70	91.38	Left Bankfull

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: JWF *Spreadsheet Computed by DF2*

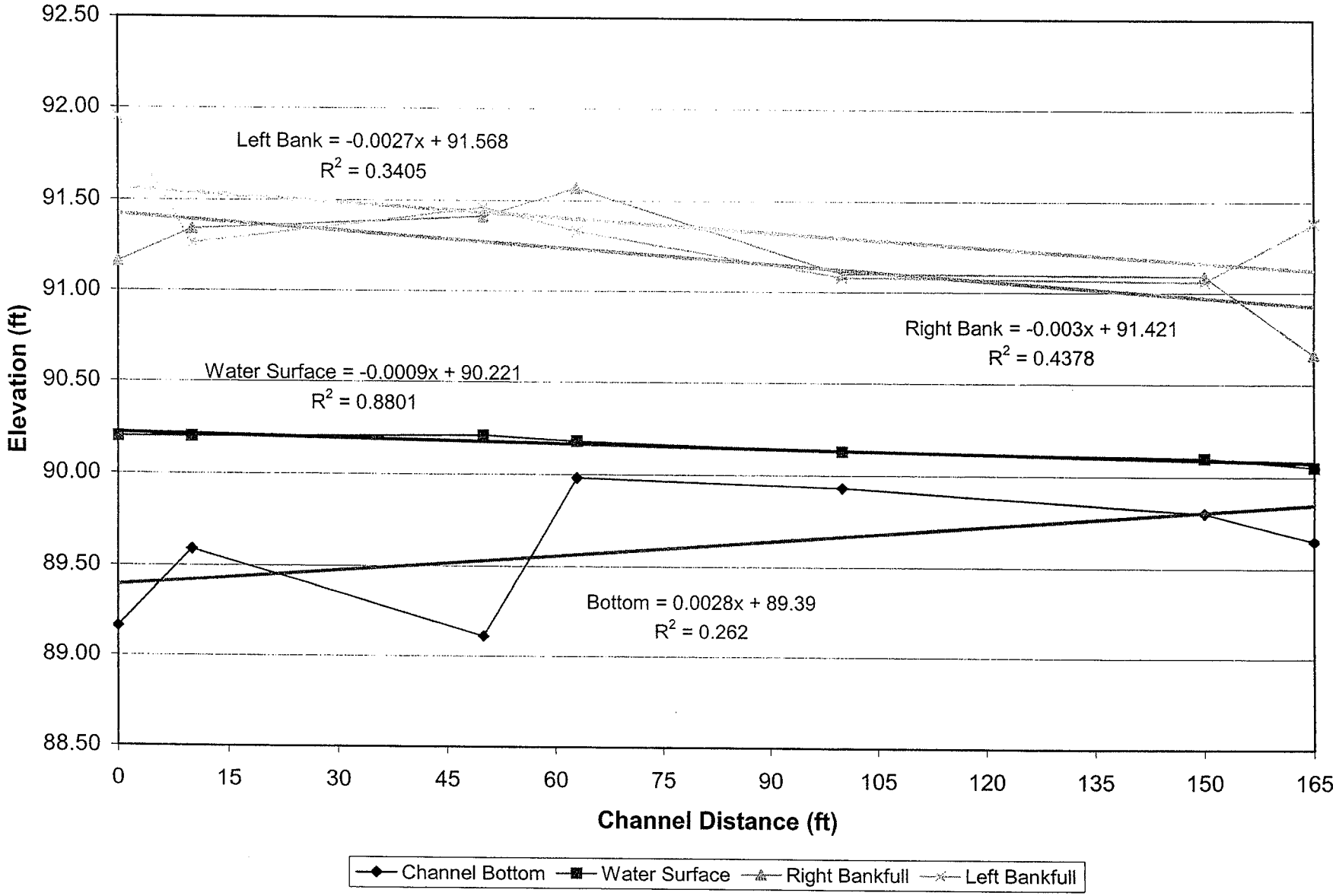
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M1) - Downstream of Springborn Road

Benchmark: 97.45 PK Nail in S. UTPL North of Road, East of Culvert

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
165			10.43	89.65	Channel Bottom
165			10.03	90.05	Water Surface
165			9.42	90.66	Right Bankfull

Marsac Creek (M1) - Reference Reach Profile



Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: JWF *Spreadsheet Computed by DF2*

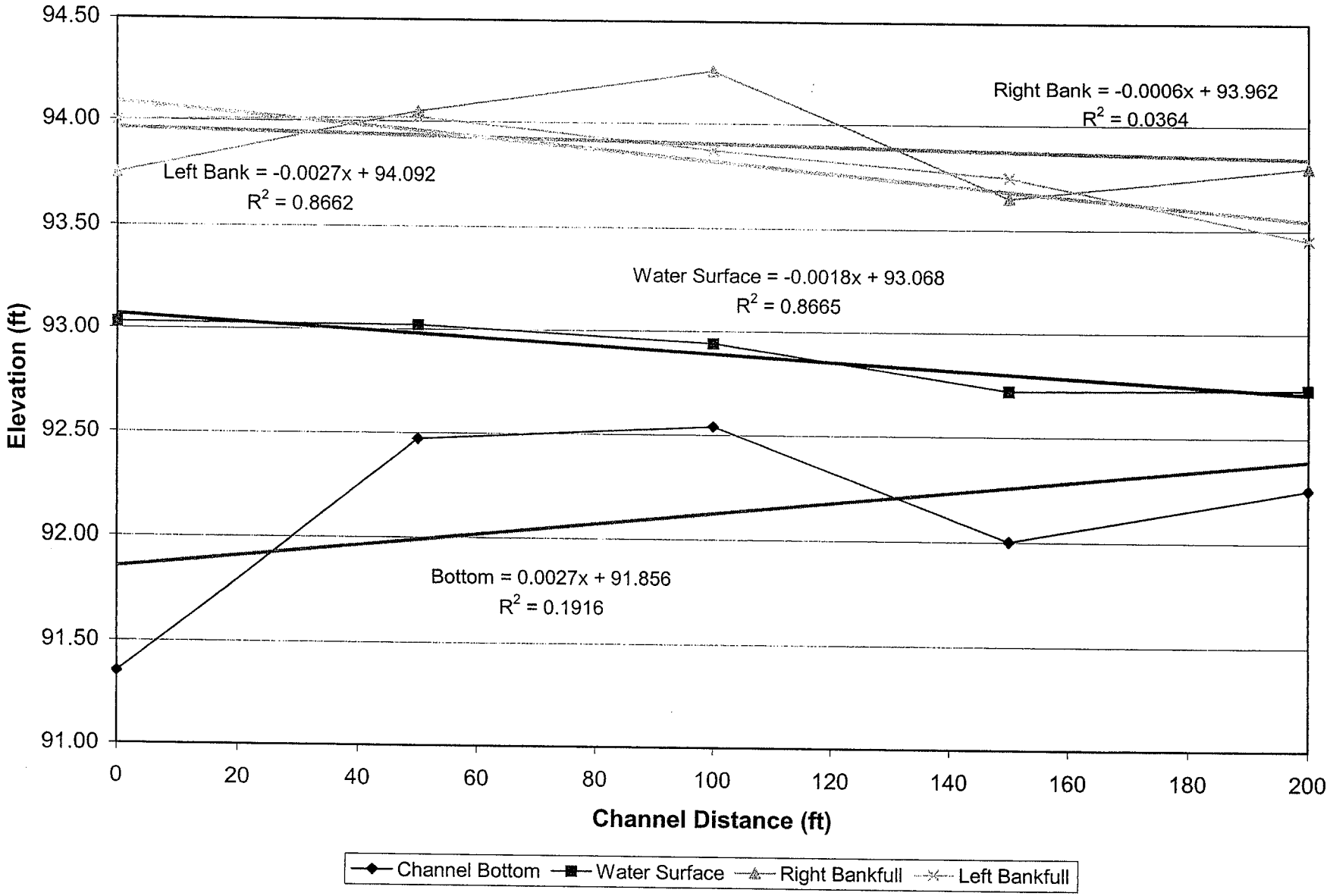
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M2) - Downstream of Marine City Highway

Benchmark: 97.52 Pink Dot - Top of 2-Track Culvert (East, D/S Side)

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
	2.48	100.00			
					14' Downstream of Culvert
0			6.00	94.00	Left Bankfull
0			8.65	91.35	Channel Bottom
0			6.97	93.03	Water Surface
0			6.25	93.75	Right Bankfull
					64' Downstream of Culvert
50			5.98	94.02	Left Bankfull
50			7.53	92.47	Channel Bottom
50			6.98	93.02	Water Surface
50			5.95	94.05	Right Bankfull
					114' Downstream of Culvert
100			6.13	93.87	Left Bankfull
100			7.46	92.54	Channel Bottom
100			7.06	92.94	Water Surface
100			5.74	94.26	Right Bankfull
					164' Downstream of Culvert
150			6.25	93.75	Left Bankfull
150			8.00	92.00	Channel Bottom
150			7.28	92.72	Water Surface
150			6.35	93.65	Right Bankfull
					End of Survey
200			6.55	93.45	Left Bankfull
200			7.75	92.25	Channel Bottom
200			7.27	92.73	Water Surface
200			6.20	93.80	Right Bankfull

Marsac Creek (M2) - Reference Reach Profile



Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/8/2004
Engineer: DF2 *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M3) - Downstream of Bethuy Road

Benchmark: 100 Top of Bolt in 8' CSP Arch

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
	3.86	103.86			
					70' Downstream of Culvert
0			10.50	93.36	Left Bankfull
0			12.73	91.13	Channel Bottom
0			11.99	91.87	Water Surface
0			9.88	93.98	Right Bankfull
					120' Downstream of Culvert
50			10.85	93.01	Left Bankfull
50			12.50	91.36	Channel Bottom
50			12.00	91.86	Water Surface
50			9.72	94.14	Right Bankfull
					148' Downstream of Culvert
78			10.67	93.19	Left Bankfull
78			12.80	91.06	Channel Bottom
78			12.01	91.85	Water Surface
78			11.25	92.61	Right Bankfull
					Top of Riffle
94			11.06	92.80	Left Bankfull
94			12.32	91.54	Channel Bottom
94			12.04	91.82	Water Surface
94			10.58	93.28	Right Bankfull
					Bottom of Riffle
110			11.01	92.85	Left Bankfull
110			13.08	90.78	Channel Bottom
110			12.21	91.65	Water Surface
110			10.75	93.11	Right Bankfull
					Pool
125			10.98	92.88	Left Bankfull
125			13.16	90.70	Channel Bottom
125			12.20	91.66	Water Surface
125			10.54	93.32	Right Bankfull
					Top of Riffle
140			11.16	92.70	Left Bankfull
140			12.50	91.36	Channel Bottom
140			12.23	91.63	Water Surface
140			10.71	93.15	Right Bankfull

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/8/2004
Engineer: DF2 *Spreadsheet Computed by DF2*

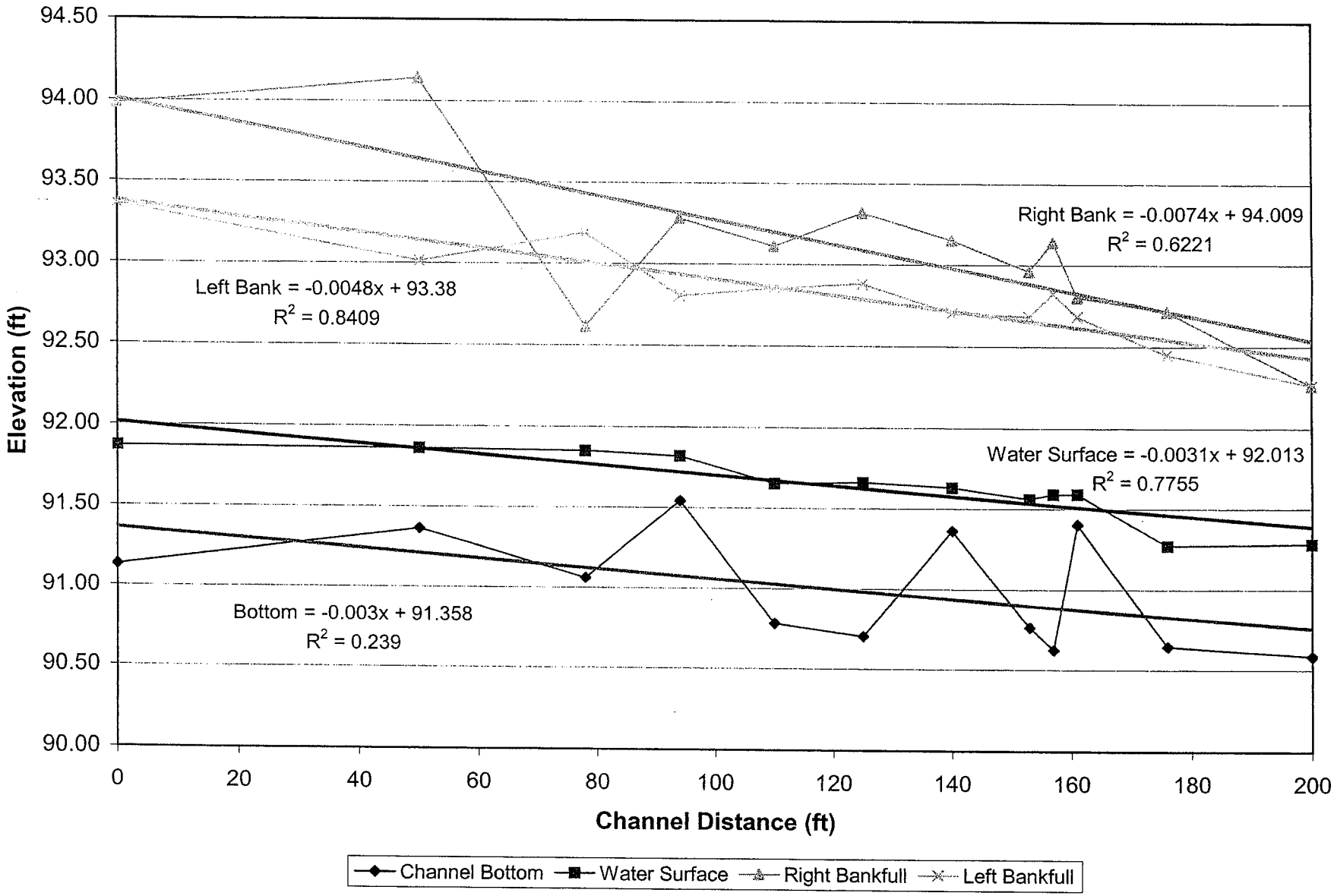
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M3) - Downstream of Bethuy Road

Benchmark: 100 Top of Bolt in 8' CSP Arch

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
					Bottom of Riffle
153			11.18	92.68	Left Bankfull
153			13.10	90.76	Channel Bottom
153			12.30	91.56	Water Surface
153			10.90	92.96	Right Bankfull
					Pool
157			11.04	92.82	Left Bankfull
157			13.24	90.62	Channel Bottom
157			12.27	91.59	Water Surface
157			10.72	93.14	Right Bankfull
					Top of Riffle
161			11.18	92.68	Left Bankfull
161			12.46	91.40	Channel Bottom
161			12.27	91.59	Water Surface
161			11.06	92.80	Right Bankfull
					Bottom of Riffle
176			11.41	92.45	Left Bankfull
176			13.22	90.64	Channel Bottom
176			12.59	91.27	Water Surface
176			11.15	92.71	Right Bankfull
					End of Survey
200			11.60	92.26	Left Bankfull
200			13.28	90.58	Channel Bottom
200			12.58	91.28	Water Surface
200			11.60	92.26	Right Bankfull

Marsac Creek (M3) - Reference Reach Profile



Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: DF2 *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Meldrum Drain (E0) - Downstream of Meisner Road

Benchmark: 100 Top of Southernmost Bolt on CSP Culvert

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
	3.62	103.62			
					115' Downstream of Culvert
0			9.01	94.61	Left Bankfull
0			10.69	92.93	Channel Bottom
0			9.94	93.68	Water Surface
0			8.82	94.80	Right Bankfull
					165' Downstream of Culvert
50			9.00	94.62	Left Bankfull
50			10.52	93.10	Channel Bottom
50			9.93	93.69	Water Surface
50			9.18	94.44	Right Bankfull
					Cross Section
61			8.91	94.71	Left Bankfull
61			10.45	93.17	Channel Bottom
61			NA	NA	Water Surface
61			9.03	94.59	Right Bankfull
					215' Downstream of Culvert
100			9.16	94.46	Left Bankfull
100			10.25	93.37	Channel Bottom
100			10.00	93.62	Water Surface
100			9.21	94.41	Right Bankfull
			9.89	93.73	Turning Point
	9.44	103.17			Re-Set
					Top of Riffle
132			8.53	94.64	Left Bankfull
132			9.63	93.54	Channel Bottom
132			9.60	93.57	Water Surface
132			8.55	94.62	Right Bankfull
					Bottom of Riffle
140			NA	NA	Left Bankfull
140			9.80	93.37	Channel Bottom
140			NA	NA	Water Surface
140			NA	NA	Right Bankfull
					Middle of Pool
155			8.89	94.28	Left Bankfull

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: DF2 *Spreadsheet Computed by DF2*

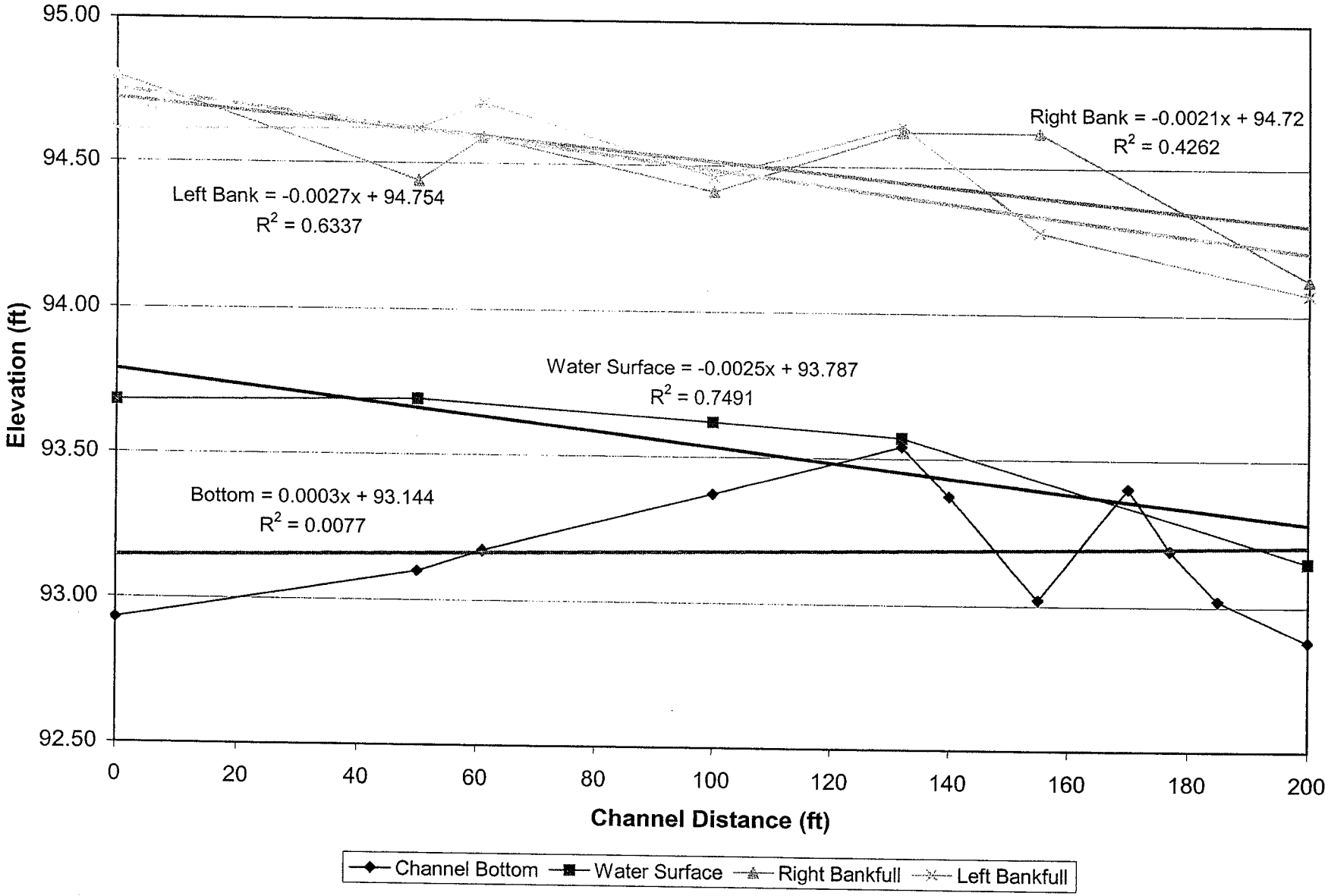
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Meldrum Drain (E0) - Downstream of Meisner Road

Benchmark: 100 Top of Southernmost Bolt on CSP Culvert

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
155			10.15	93.02	Channel Bottom
155			NA	NA	Water Surface
155			8.55	94.62	Right Bankfull
					Top of Riffle
170			NA	NA	Left Bankfull
170			9.77	93.40	Channel Bottom
170			NA	NA	Water Surface
170			NA	NA	Right Bankfull
					Bottom of Riffle
177			NA	NA	Left Bankfull
177			9.98	93.19	Channel Bottom
177			NA	NA	Water Surface
177			NA	NA	Right Bankfull
					Middle of Pool
182			NA	NA	Left Bankfull
182			NA	NA	Channel Bottom
182			NA	NA	Water Surface
182			NA	NA	Right Bankfull
					Top of Riffle
185			NA	NA	Left Bankfull
185			10.15	93.02	Channel Bottom
185			NA	NA	Water Surface
185			NA	NA	Right Bankfull
					End of Survey
200			9.10	94.07	Left Bankfull
200			10.29	92.88	Channel Bottom
200			10.02	93.15	Water Surface
200			9.05	94.12	Right Bankfull

Meldrum Drain (E0) - Reference Reach Profile



Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: KEE *Spreadsheet Computed by DF2*

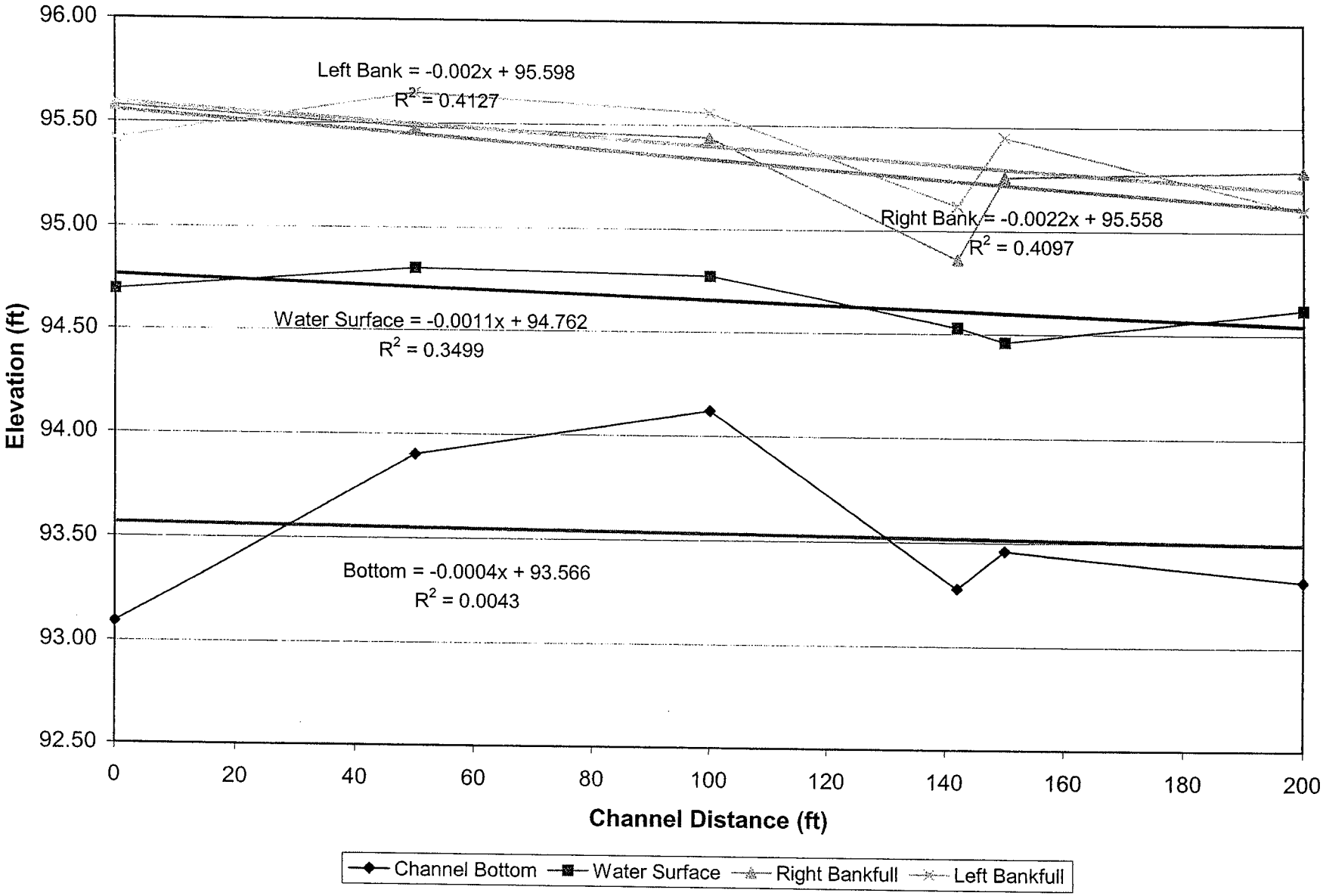
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Salt River (S1) - Downstream of 30 Mile Road

Benchmark: 100 PK Nail in Power Pole, NW of Culvert

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
	0.33	100.33			
					115' Downstream of Culvert
0			4.91	95.42	Left Bankfull
0			7.24	93.09	Channel Bottom
0			5.64	94.69	Water Surface
0			4.75	95.58	Right Bankfull
	0	100			Re-Set
					165' Downstream of Culvert
50			4.35	95.65	Left Bankfull
50			6.10	93.90	Channel Bottom
50			5.20	94.80	Water Surface
50			4.52	95.48	Right Bankfull
					215' Downstream of Culvert
100			4.44	95.56	Left Bankfull
100			5.88	94.12	Channel Bottom
100			5.23	94.77	Water Surface
100			4.56	95.44	Right Bankfull
					Cross Section
142			4.88	95.12	Left Bankfull
142			6.72	93.28	Channel Bottom
142			5.47	94.53	Water Surface
142			5.14	94.86	Right Bankfull
					265' Downstream of Culvert
150			4.55	95.45	Left Bankfull
150			6.54	93.46	Channel Bottom
150			5.54	94.46	Water Surface
150			4.74	95.26	Right Bankfull
					End of Survey
200			4.90	95.10	Left Bankfull
200			6.68	93.32	Channel Bottom
200			5.38	94.62	Water Surface
200			4.71	95.29	Right Bankfull

Salt River (S1) - Reference Reach Profile



Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: JWF *Spreadsheet Computed by DF2*

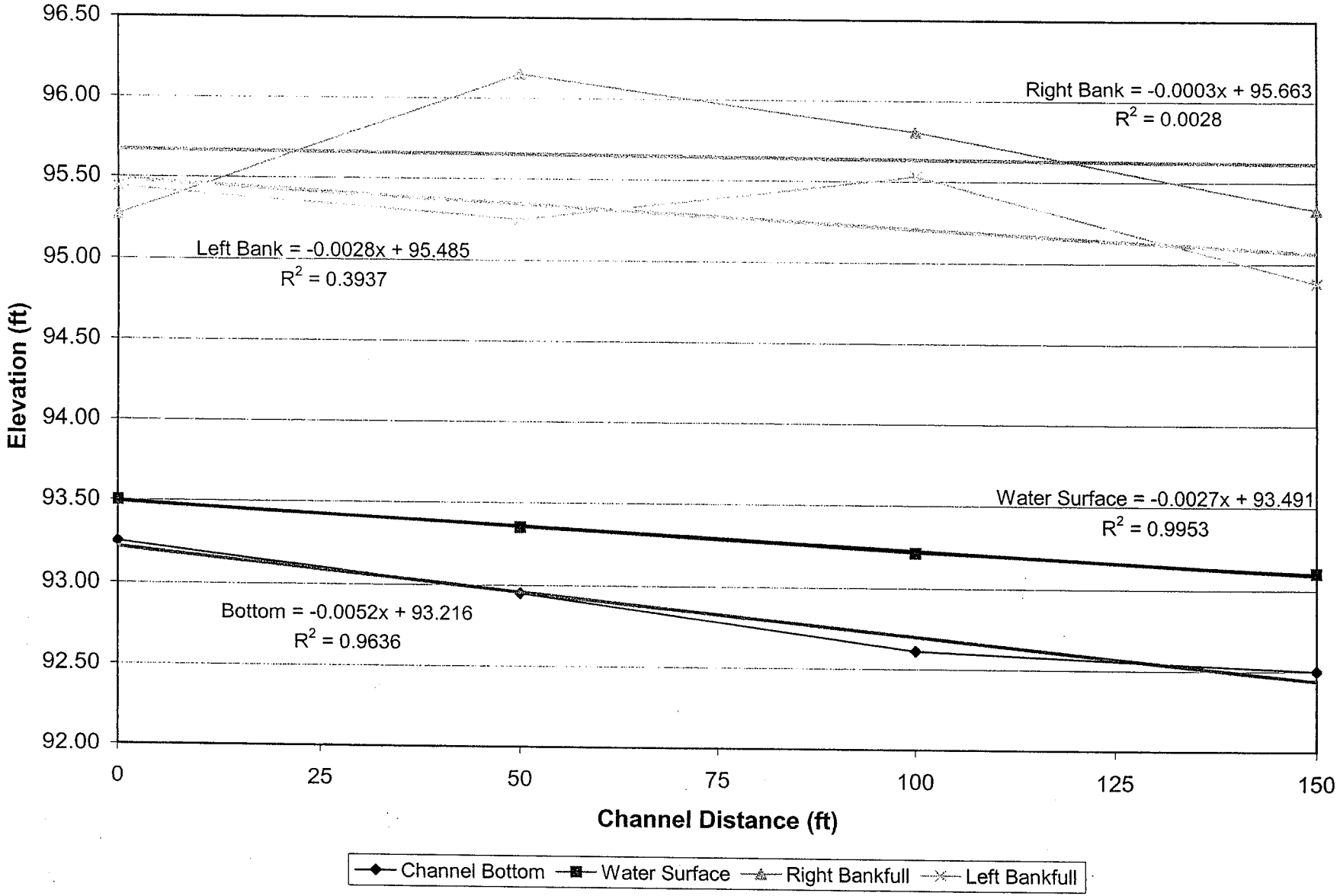
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Salt River (S2) - Downstream of 29 Mile Road

Benchmark: 100 Pink Mark - SW Bridge Abutment

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
	0.75	100.75			
					Begin Survey
0			5.31	95.44	Left Bankfull
0			7.50	93.25	Channel Bottom
0			7.25	93.50	Water Surface
0			5.48	95.27	Right Bankfull
					50' Downstream
50			5.50	95.25	Left Bankfull
50			7.80	92.95	Channel Bottom
50			7.40	93.35	Water Surface
50			4.60	96.15	Right Bankfull
					100' Downstream
100			5.22	95.53	Left Bankfull
100			8.14	92.61	Channel Bottom
100			7.54	93.21	Water Surface
100			4.95	95.80	Right Bankfull
					End of Survey
150			5.87	94.88	Left Bankfull
150			8.25	92.50	Channel Bottom
150			7.65	93.10	Water Surface
150			5.42	95.33	Right Bankfull

Salt River (S2) - Reference Reach Profile



Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: JWF *Spreadsheet Computed by DF2*

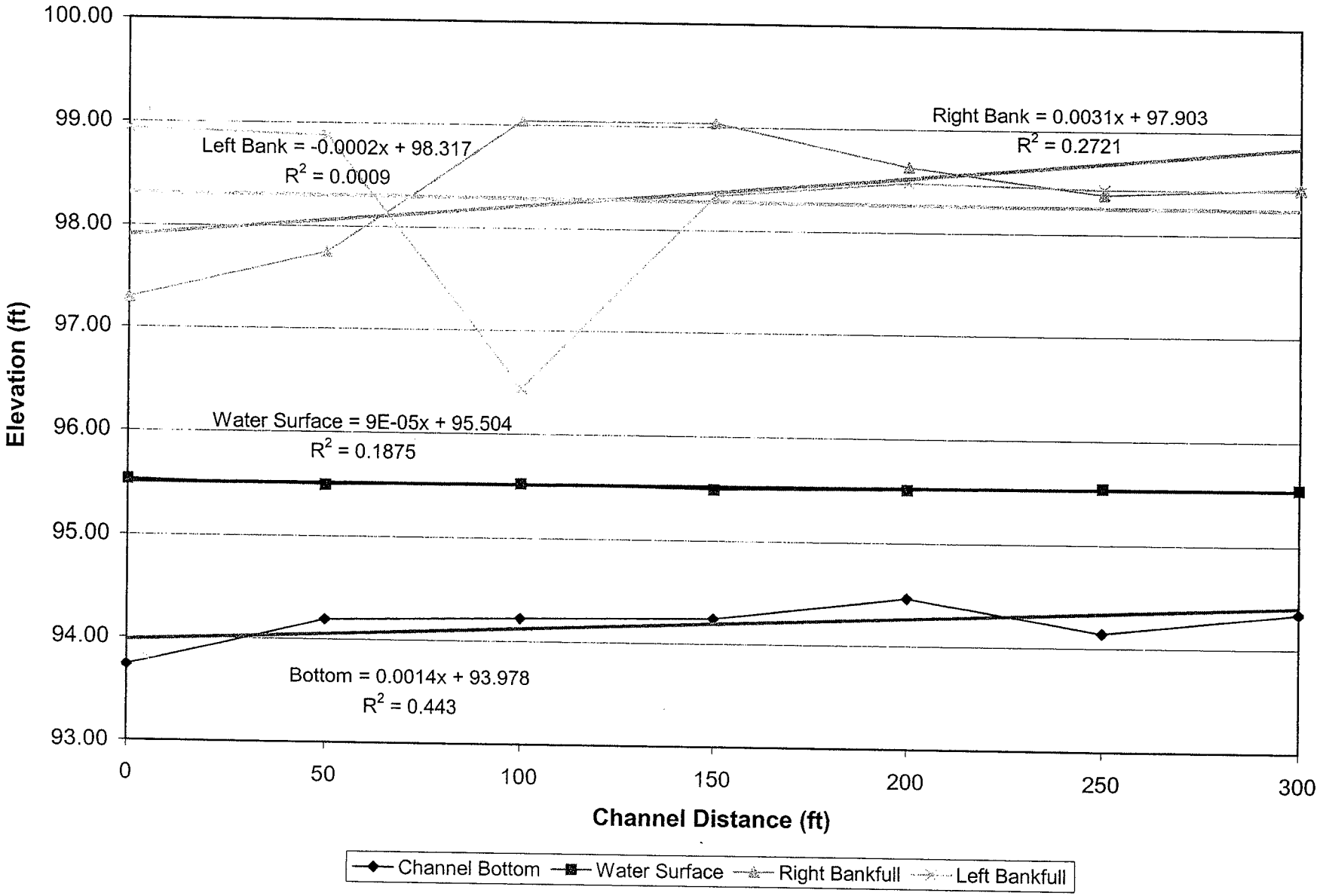
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Salt River (S4) - Downstream of M-19

Benchmark: 100 48" Maple Stump

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
	1.24	101.24			
					70' Downstream of Bridge
0			2.30	98.94	Left Bankfull
0			7.51	93.73	Channel Bottom
0			5.71	95.53	Water Surface
0			3.95	97.29	Right Bankfull
					120' Downstream of Bridge
50			2.36	98.88	Left Bankfull
50			7.05	94.19	Channel Bottom
50			5.75	95.49	Water Surface
50			3.49	97.75	Right Bankfull
					170' Downstream of Bridge
100			4.80	96.44	Left Bankfull
100			7.02	94.22	Channel Bottom
100			5.72	95.52	Water Surface
100			2.20	99.04	Right Bankfull
					220' Downstream of Bridge
150			2.90	98.34	Left Bankfull
150			7.00	94.24	Channel Bottom
150			5.75	95.49	Water Surface
150			2.20	99.04	Right Bankfull
					270' Downstream of Bridge
200			2.75	98.49	Left Bankfull
200			6.78	94.46	Channel Bottom
200			5.73	95.51	Water Surface
200			2.60	98.64	Right Bankfull
					320' Downstream of Bridge
250			2.80	98.44	Left Bankfull
250			7.10	94.14	Channel Bottom
250			5.70	95.54	Water Surface
250			2.85	98.39	Right Bankfull
					End of Survey
300			2.80	98.44	Left Bankfull
300			6.90	94.34	Channel Bottom
300			5.70	95.54	Water Surface
300			2.78	98.46	Right Bankfull

Salt River (S4) - Reference Reach Profile



Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: KEE *Spreadsheet Computed by DF2*

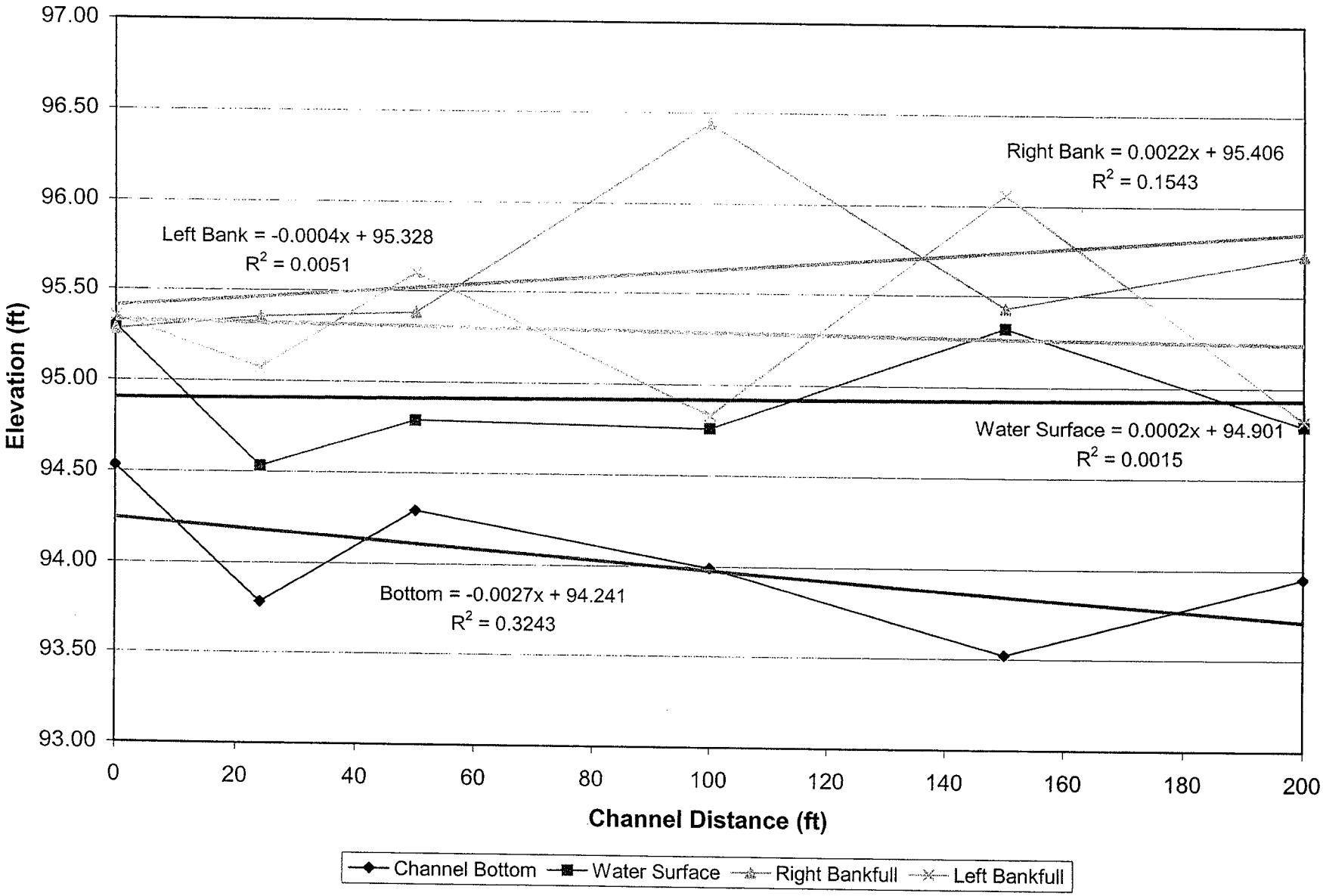
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Swan Creek (W0) - Downstream of Meldrum Road

Benchmark: 100 PK Nail in Power Pole, NE of Culvert

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
	1.83	101.83			
					47' Downstream of Culvert
0			6.48	95.35	Left Bankfull
0			7.30	94.53	Channel Bottom
0			6.53	95.30	Water Surface
0			6.55	95.28	Right Bankfull
					Cross Section
24			6.76	95.07	Left Bankfull
24			8.05	93.78	Channel Bottom
24			7.30	94.53	Water Surface
24			6.48	95.35	Right Bankfull
					97' Downstream of Culvert
50			6.23	95.60	Left Bankfull
50			7.54	94.29	Channel Bottom
50			7.04	94.79	Water Surface
50			6.45	95.38	Right Bankfull
					147' Downstream of Culvert
100			7.00	94.83	Left Bankfull
100			7.84	93.99	Channel Bottom
100			7.07	94.76	Water Surface
100			5.39	96.44	Right Bankfull
					197' Downstream of Culvert
150			5.77	96.06	Left Bankfull
150			8.31	93.52	Channel Bottom
150			6.51	95.32	Water Surface
150			6.40	95.43	Right Bankfull
					End of Survey
200			7.01	94.82	Left Bankfull
200			7.88	93.95	Channel Bottom
200			7.04	94.79	Water Surface
200			6.10	95.73	Right Bankfull

Swan Creek (W0) - Reference Reach Profile



Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: NGJ *Spreadsheet Computed by DF2*

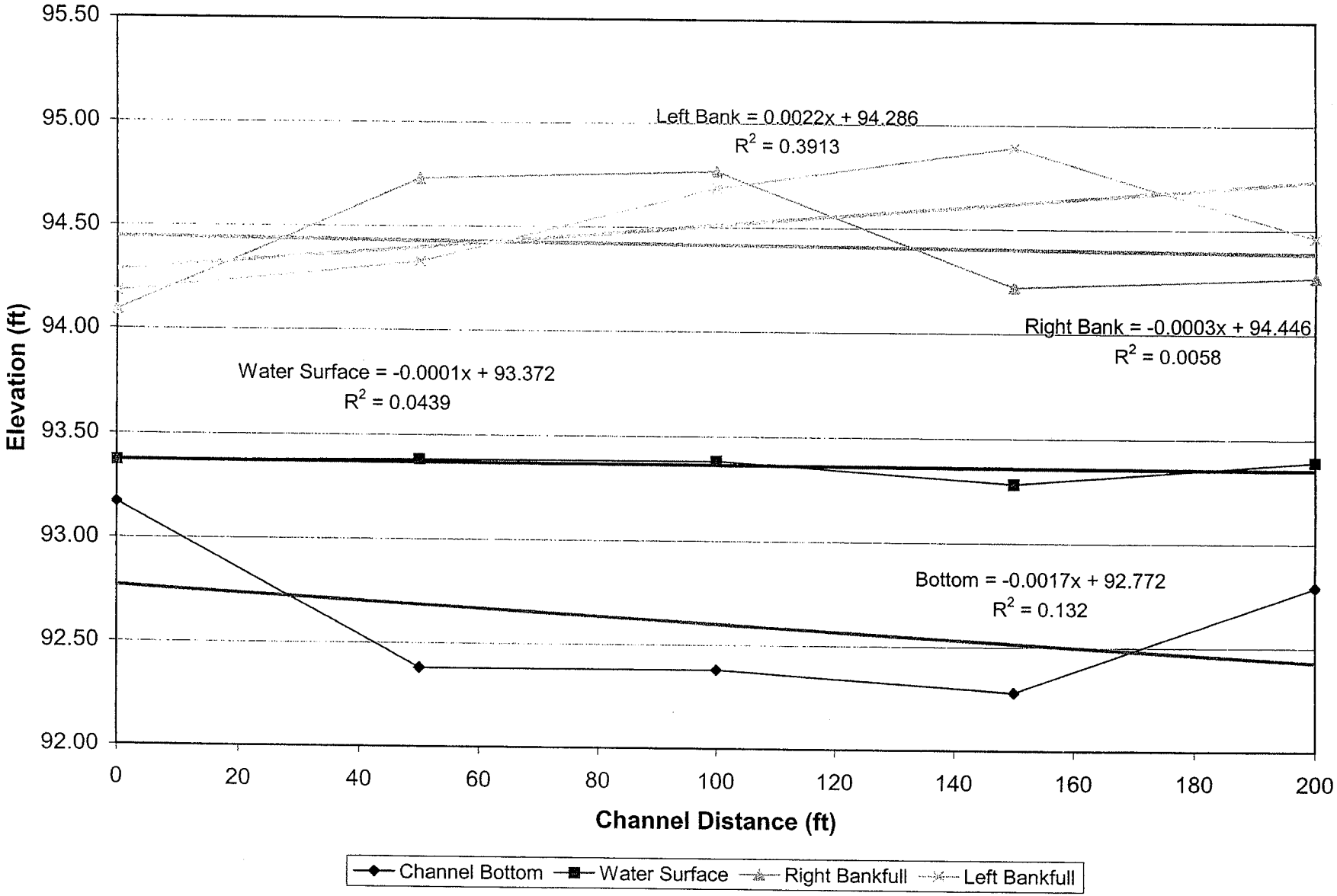
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Swan Creek (W2) - Downstream of Lindsey Road

Benchmark: 100 SW Wingwall of Lindsey Road Bridge

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
	1.87	101.87			
					34' Downstream of Crossing
0			7.69	94.18	Left Bankfull
0			8.70	93.17	Channel Bottom
0			8.50	93.37	Water Surface
0			7.78	94.09	Right Bankfull
					84' Downstream of Crossing
50			7.54	94.33	Left Bankfull
50			9.49	92.38	Channel Bottom
50			8.49	93.38	Water Surface
50			7.14	94.73	Right Bankfull
					134' Downstream of Crossing
100			7.18	94.69	Left Bankfull
100			9.49	92.38	Channel Bottom
100			8.49	93.38	Water Surface
100			7.10	94.77	Right Bankfull
					184' Downstream of Crossing
150			6.98	94.89	Left Bankfull
150			9.59	92.28	Channel Bottom
150			8.59	93.28	Water Surface
150			7.65	94.22	Right Bankfull
					End of Survey
200			7.41	94.46	Left Bankfull
200			9.08	92.79	Channel Bottom
200			8.48	93.39	Water Surface
200			7.60	94.27	Right Bankfull

Swan Creek (W2) - Reference Reach Profile



Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: NGJ *Spreadsheet Computed by DF2*

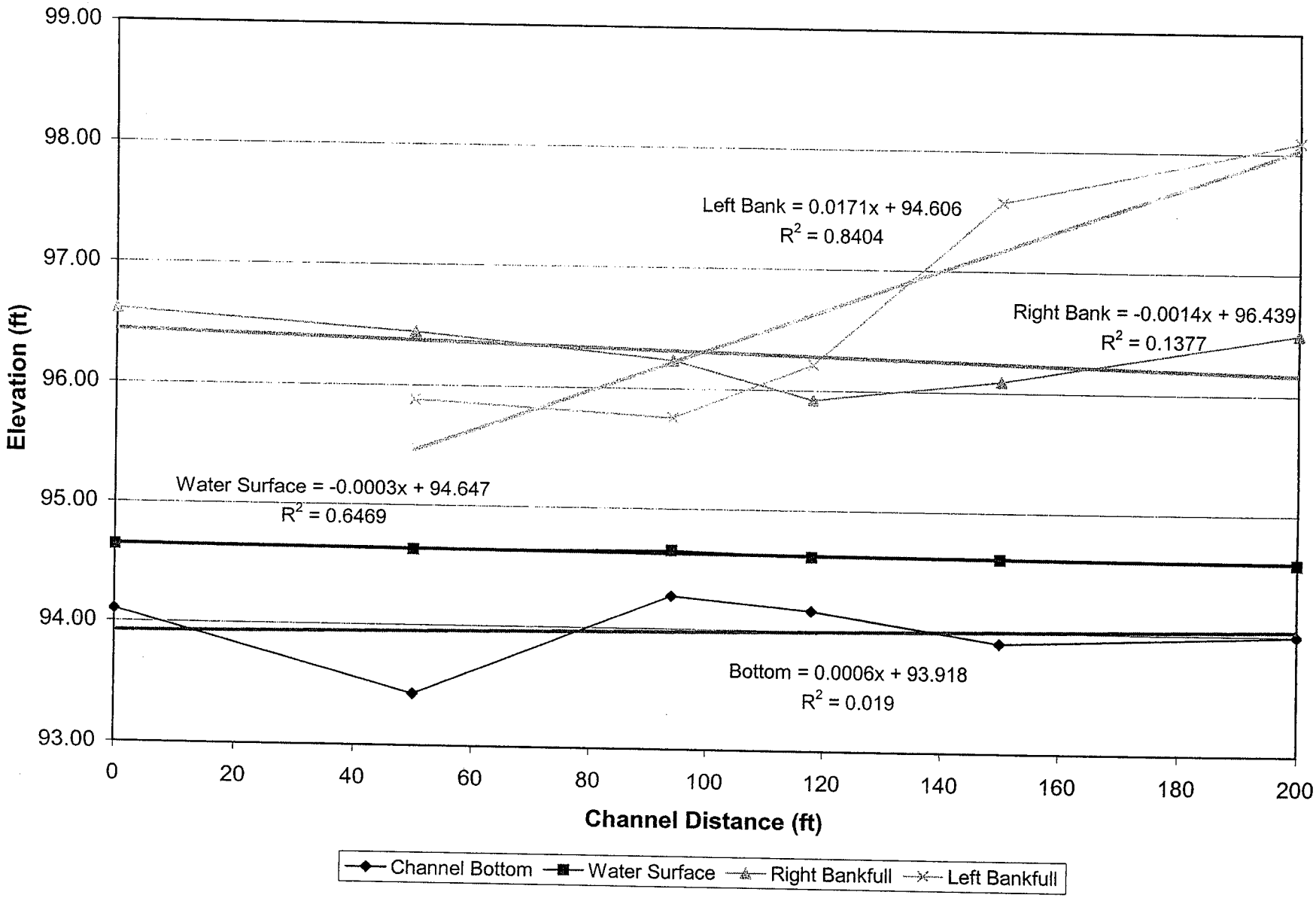
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Swan Creek (W3) - Downstream of Palms Road

Benchmark: 100 4" Maple at Station 0+80 - West Side

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
	1.26	101.26			
					Begin Survey
0			NA	NA	Left Bankfull
0			7.16	94.10	Channel Bottom
0			6.62	94.64	Water Surface
0			4.65	96.61	Right Bankfull
					50' Downstream
50			5.38	95.88	Left Bankfull
50			7.83	93.43	Channel Bottom
50			6.63	94.63	Water Surface
50			4.82	96.44	Right Bankfull
					Top of Riffle
94			5.50	95.76	Left Bankfull
94			6.99	94.27	Channel Bottom
94			6.61	94.65	Water Surface
94			5.03	96.23	Right Bankfull
					Bottom of Riffle
118			5.05	96.21	Left Bankfull
118			7.10	94.16	Channel Bottom
118			6.65	94.61	Water Surface
118			5.34	95.92	Right Bankfull
					150' Downstream
150			3.69	97.57	Left Bankfull
150			7.35	93.91	Channel Bottom
150			6.65	94.61	Water Surface
150			5.17	96.09	Right Bankfull
					End of Survey
200			3.17	98.09	Left Bankfull
200			7.27	93.99	Channel Bottom
200			6.67	94.59	Water Surface
200			4.76	96.50	Right Bankfull

Swan Creek (W3) - Reference Reach Profile



Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: NGJ *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Swan Creek (W6) - Downstream of Short Cut Road

Benchmark: 100 SE Corner of SE Wingwall of Bridge

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
	0.28	100.28			First Setup
			7.36	92.92	Turning Point
	1.92	94.84			Second Setup
					85' Downstream of Bridge
0			7.34	92.94	Left Bankfull
0			10.94	89.34	Channel Bottom
0			8.22	92.06	Water Surface
0			7.36	92.92	Right Bankfull
					135' Downstream of Bridge
50			7.28	93.00	Left Bankfull
50			10.76	89.52	Channel Bottom
50			8.21	92.07	Water Surface
50			7.18	93.10	Right Bankfull
					185' Downstream of Bridge
100			7.30	92.98	Left Bankfull
100			9.48	90.80	Channel Bottom
100			8.20	92.08	Water Surface
100			7.86	92.42	Right Bankfull
					235' Downstream of Bridge
150			7.28	93.00	Left Bankfull
150			10.12	90.16	Channel Bottom
150			8.22	92.06	Water Surface
150			2.19	92.65	Right Bankfull
					285' Downstream of Bridge
200			7.50	92.78	Left Bankfull
200			9.61	90.67	Channel Bottom
200			8.21	92.07	Water Surface
200			2.23	92.61	Right Bankfull
					335' Downstream of Bridge
250			7.38	92.90	Left Bankfull
250			10.28	90.00	Channel Bottom
250			8.23	92.05	Water Surface
250			2.09	92.75	Right Bankfull
					385' Downstream of Bridge
300			1.95	92.89	Left Bankfull

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: NGJ *Spreadsheet Computed by DF2*

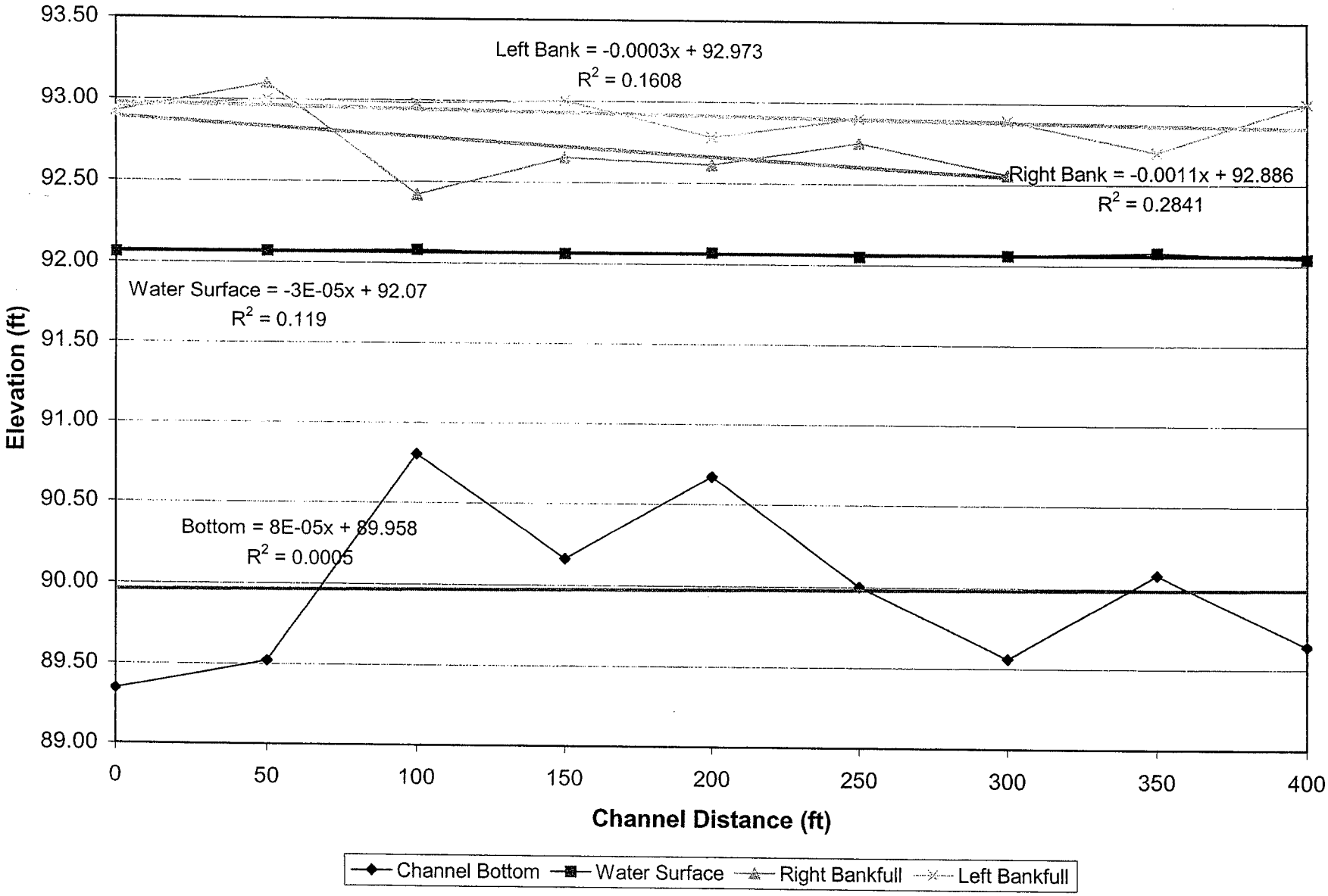
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Swan Creek (W6) - Downstream of Short Cut Road

Benchmark: 100 SE Corner of SE Wingwall of Bridge

Station	B.S. (+)	H.I.	F.S. (-)	Elevation	Description
300			10.72	89.56	Channel Bottom
300			8.22	92.06	Water Surface
300			7.72	92.56	Right Bankfull
					435' Downstream of Bridge
350			2.14	92.70	Left Bankfull
350			10.20	90.08	Channel Bottom
350			8.20	92.08	Water Surface
350			NA	NA	Right Bankfull
					End of Survey
400			1.84	93.00	Left Bankfull
400			10.64	89.64	Channel Bottom
400			8.24	92.04	Water Surface
400			NA	NA	Right Bankfull

Swan Creek (W6) - Reference Reach Profile



Appendix 3: Reference Reach Longitudinal Survey

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: JMH *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Beaubien Creek (B2) - Downstream of Arnold Road

Benchmark: 100 Bolt on Top of South End (Outlet) of Culvert

Project Description	
Worksheet	Beaubien Creek (B2) - Sta. 0+61 Cross Section
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.033
Channel Slope	0.0036 ft/ft
Water Surface Elevation	97.21 ft
Bottom Elevation	94.94 ft
Discharge	102.77 cfs

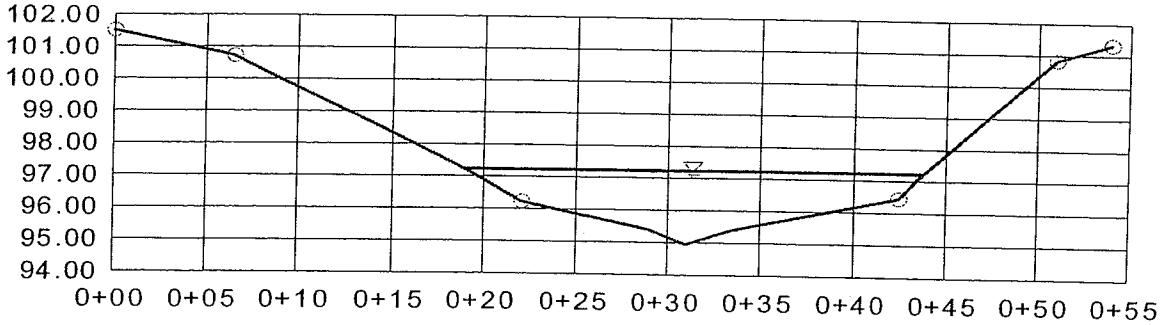
Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+07	0.06
0+07	0+22	0.045
0+22	0+43	0.03
0+43	0+51	0.045
0+51	0+54	0.06

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	101.51
0+07	100.76
0+19	97.21
0+22	96.25
0+29	95.39
0+31	94.94
0+34	95.42
0+43	96.44
0+44	97.08
0+51	100.83
0+54	101.34

Bankfull Elements	
Bankfull Area	32.3 ft^2
Bankfull Width	24.76 ft
Bankfull Depth	2.27 ft



Typical Cross Section

V:2.0
H:1
NTS

- *Data computed using the FlowMaster Computer Program*

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: JMH *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Beaubien Creek (B5) - Downstream of Starville Road

Benchmark: 100 SW Corner of Bridge Abutment

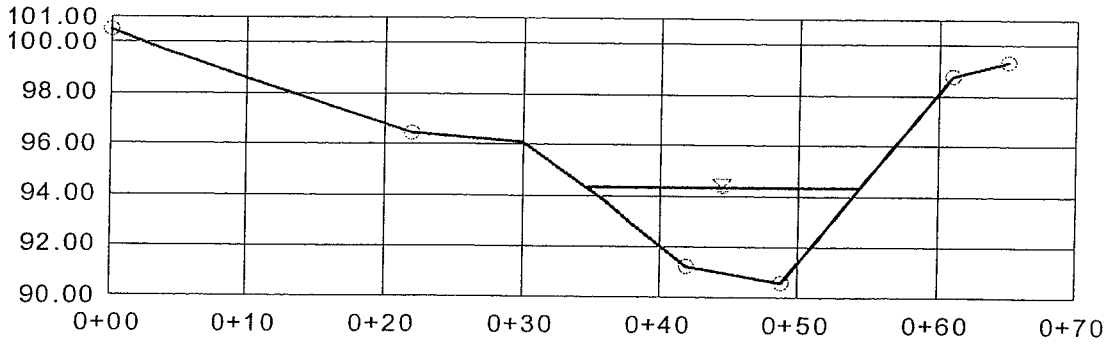
Project Description	
Worksheet	Beaubien Creek (B5) - Sta. 0+19 Cross Section
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.04
Channel Slope	0.0028 ft/ft
Water Surface Elevation	94.3 ft
Bottom Elevation	90.61 ft
Discharge	142.32 cfs

Roughness Segments		
Start Station	**End Station**	**Mannings Coefficient**
0+00	0+22	0.06
0+22	0+42	0.045
0+42	0+49	0.03
0+49	0+61	0.045
0+61	0+65	0.06

Natural Channel Points	
Station (ft)	**Elevation (ft)**
0+00	100.54
0+04	99.69
0+22	96.46
0+30	96.1
0+36	93.85
0+38	92.92
0+42	91.22
0+49	90.61
0+61	98.74
0+65	99.32

Bankfull Elements	
Bankfull Area	44.8 ft^2
Bankfull Width	19.65 ft
Bankfull Depth	3.69 ft



Typical Cross Section

V:2.0
H:1
NTS

- *Data computed using the FlowMaster Computer Program*

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: JWF *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M1) - Downstream of Springborn Road

Benchmark: 97.45 PK Nail in S. UTPL North of Road, East of Culvert

Project Description	
Worksheet	Marsac Creek (M1) - Sta. 0+10 Cross Section
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.031
Channel Slope	0.0009 ft/ft
Water Surface Elevation	91.34 ft
Bottom Elevation	89.59 ft
Discharge	10.12 cfs

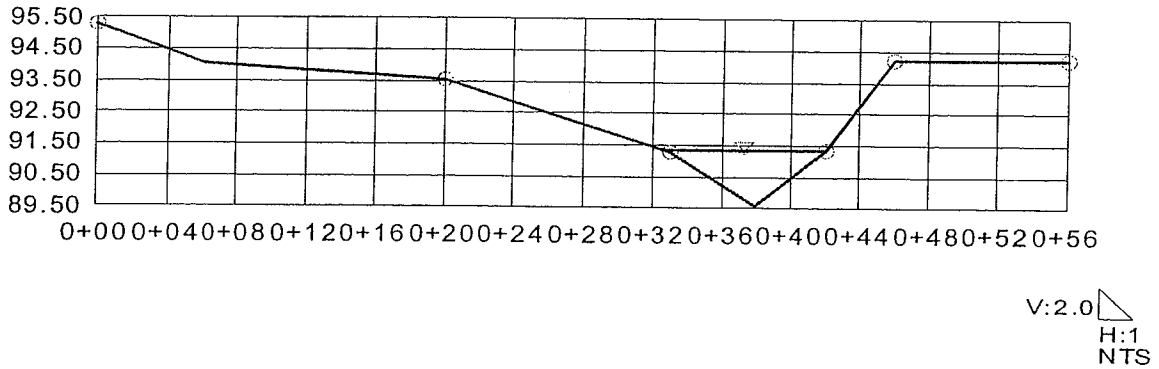
Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+20	0.06
0+20	0+33	0.045
0+33	0+42	0.03
0+42	0+46	0.045
0+46	0+56	0.035

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	95.3
0+06	94.01
0+20	93.53
0+33	91.26
0+38	89.59
0+42	91.34
0+46	94.22
0+56	94.23

Bankfull Elements	
Bankfull Area	8.1 ft^2
Bankfull Width	9.46 ft
Bankfull Depth	1.75 ft



Typical Cross Section

- *Data computed using the FlowMaster Computer Program*

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: JWF *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M2) - Downstream of Marine City Highway

Benchmark: 97.52 Pink Dot - Top of 2-Track Culvert (East, D/S Side)

Project Description	
Worksheet	Marsac Creek (M2) - Sta. 0+67 Cross Section
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.032
Channel Slope	0.0018 ft/ft
Water Surface Elevation	93.9 ft
Bottom Elevation	92.58 ft
Discharge	20.48 cfs

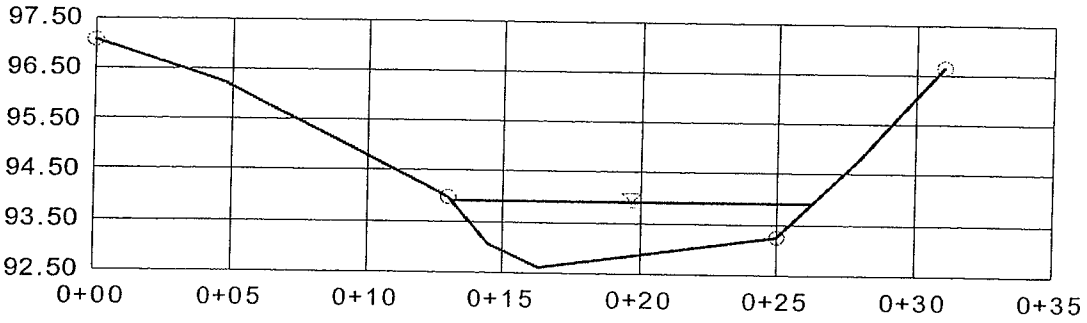
Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+13	0.045
0+13	0+25	0.03
0+25	0+31	0.045

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	97.08
0+05	96.2
0+13	93.97
0+15	93.05
0+16	92.58
0+25	93.25
0+28	94.82
0+31	96.65

Bankfull Elements	
Bankfull Area	11.5 ft^2
Bankfull Width	13.13 ft
Bankfull Depth	1.32 ft



Typical Cross Section

V:2.0
H:1
NTS

- *Data computed using the FlowMaster Computer Program*

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/8/2004
Engineer: DF2 *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M3) - Downstream of Bethuy Road

Benchmark: 100 Top of Bolt in 8' CSP Arch

Project Description	
Worksheet	Marsac Creek (M3) - Sta. 0+50 Cross Section
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.032
Channel Slope	0.0031 ft/ft
Water Surface Elevation	94 ft
Bottom Elevation	91.41 ft
Discharge	56.11 cfs

Roughness Segments

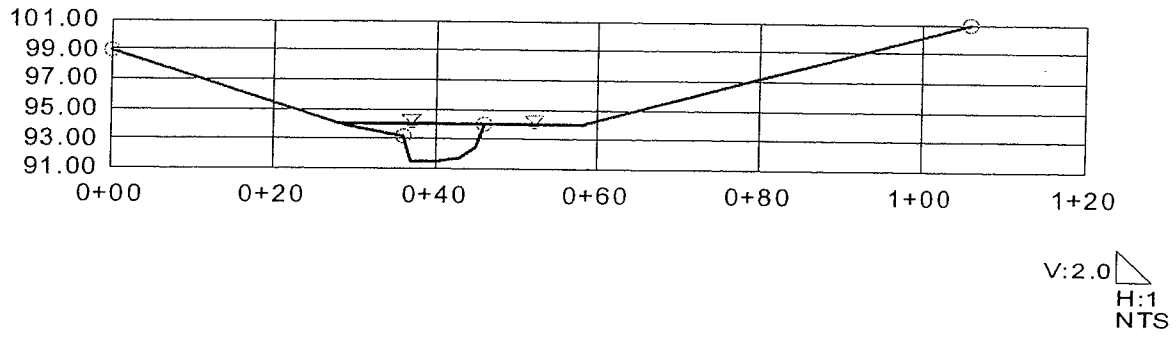
Start Station	End Station	Mannings Coefficient
0+00	0+36	0.035
0+36	0+46	0.03
0+46	1+06	0.035

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	98.91
0+29	93.83
0+36	93.2
0+37	91.46
0+40	91.41
0+43	91.68
0+45	92.42
0+46	94
0+58	93.93
1+06	100.94

Bankfull Elements

Bankfull Area	25.3 ft^2
Bankfull Width	30.45 ft
Bankfull Depth	2.59 ft



Typical Cross Section

- *Data computed using the FlowMaster Computer Program*

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: DF2 *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Meldrum Drain (E0) - Downstream of Meisner Road

Benchmark: 100 Top of Southernmost Bolt on CSP Culvert

Project Description	
Worksheet	Meldrum Drain (E0) - Sta. 0+61 Cross Section
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.03
Channel Slope	0.0025 ft/ft
Water Surface Elevation	94.59 ft
Bottom Elevation	93.17 ft
Discharge	32.14 cfs

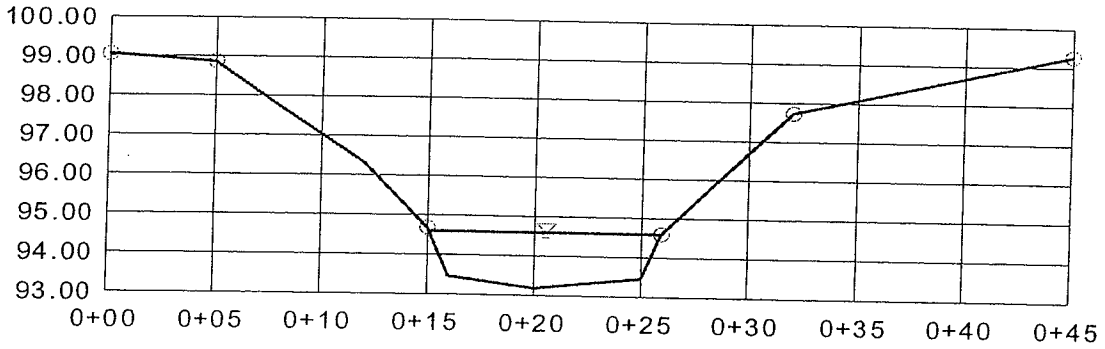
Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+05	0.06
0+05	0+15	0.045
0+15	0+26	0.03
0+26	0+32	0.045
0+32	0+45	0.06

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	99.04
0+05	98.87
0+12	96.34
0+15	94.71
0+16	93.44
0+20	93.17
0+25	93.47
0+26	94.59
0+32	97.74
0+45	99.3

Bankfull Elements	
Bankfull Area	12.6 ft^2
Bankfull Width	10.91 ft
Bankfull Depth	1.42 ft



Typical Cross Section

V:2.0
H:1
NTS

- *Data computed using the FlowMaster Computer Program*

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: KEE *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Salt River (S1) - Downstream of 30 Mile Road

Benchmark: 100 PK Nail in Power Pole, NW of Culvert

Project Description	
Worksheet	Salt River (S1) - Sta. 1+42 Cross Section
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.048
Channel Slope	0.0011 ft/ft
Water Surface Elevation	95.12 ft
Bottom Elevation	93.28 ft
Discharge	8.56 cfs

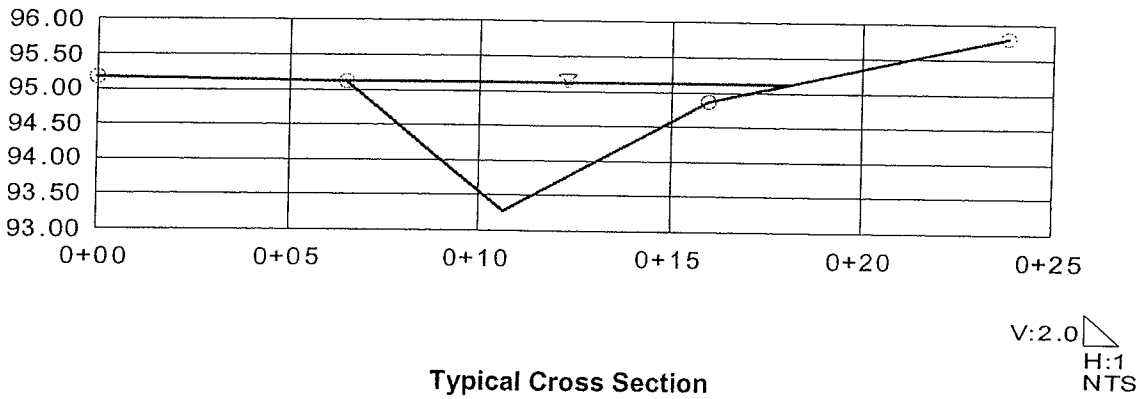
Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+07	0.06
0+07	0+16	0.045
0+16	0+24	0.06

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	95.18
0+07	95.12
0+11	93.28
0+16	94.86
0+24	95.81

Bankfull Elements	
Bankfull Area	9.7 ft^2
Bankfull Width	11.63 ft
Bankfull Depth	1.84 ft



Typical Cross Section

- *Data computed using the FlowMaster Computer Program*

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: JWF *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Salt River (S2) - Downstream of 29 Mile Road

Benchmark: 100 Pink Mark - SW Bridge Abutment

Project Description	
Worksheet	Salt River (S2) - Sta. 1+25 Cross Section
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.038
Channel Slope	0.0027 ft/ft
Water Surface Elevation	94.52 ft
Bottom Elevation	92.71 ft
Discharge	25.59 cfs

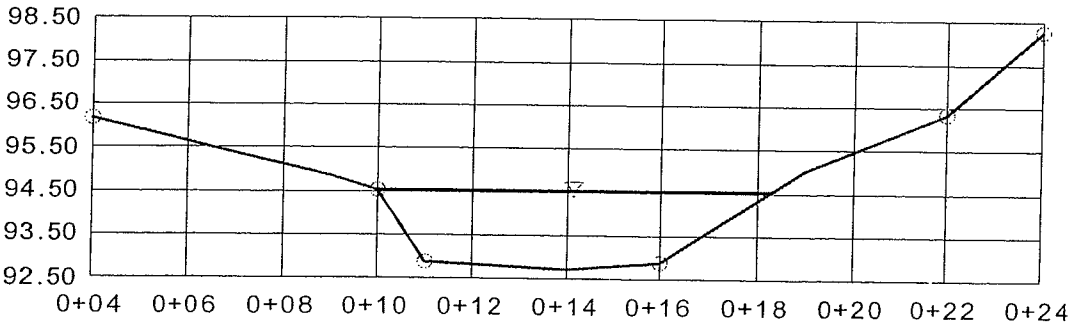
Roughness Segments

Start Station	End Station	Mannings Coefficient
0+04	0+10	0.06
0+10	0+11	0.045
0+11	0+16	0.03
0+16	0+22	0.045
0+22	0+24	0.06

Natural Channel Points

Station (ft)	Elevation (ft)
0+04	96.15
0+09	94.85
0+10	94.52
0+11	92.89
0+14	92.71
0+16	92.88
0+19	95.03
0+22	96.35
0+24	98.25

Bankfull Elements	
Bankfull Area	11.3 ft^2
Bankfull Width	8.29 ft
Bankfull Depth	1.81 ft



Typical Cross Section

V:1
H:1
NTS

- *Data computed using the FlowMaster Computer Program*

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: JWF *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Salt River (S4) - Downstream of M-19

Benchmark: 100 48" Maple Stump

Project Description	
Worksheet	Salt River (S4) - Sta. 0+70 Cross Section
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.03
Channel Slope	0.00009 ft/ft
Water Surface Elevation	96.22 ft
Bottom Elevation	94.38 ft
Discharge	23.25 cfs

Roughness Segments

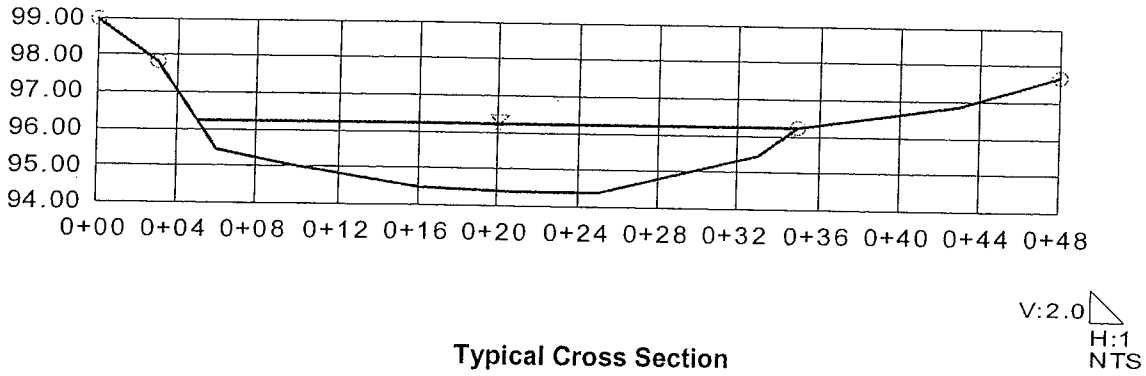
Start Station	End Station	Mannings Coefficient
0+00	0+03	0.06
0+03	0+35	0.03
0+35	0+48	0.06

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	99
0+03	97.81
0+06	95.46
0+10	94.99
0+16	94.49
0+21	94.38
0+25	94.38
0+33	95.44
0+35	96.22
0+43	96.87
0+48	97.69

Bankfull Elements

Bankfull Area	40.8 ft^2
Bankfull Width	29.97 ft
Bankfull Depth	1.84 ft



Typical Cross Section

- *Data computed using the FlowMaster Computer Program*

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: KEE *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Swan Creek (W0) - Downstream of Meldrum Road

Benchmark: 100 PK Nail in Power Pole, NE of Culvert

Project Description	
Worksheet	Swan Creek (W0) - Sta. 0+24 Cross Section
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.045
Channel Slope	0.0027 ft/ft
Water Surface Elevation	95.35 ft
Bottom Elevation	93.78 ft
Discharge	17 cfs

Roughness Segments

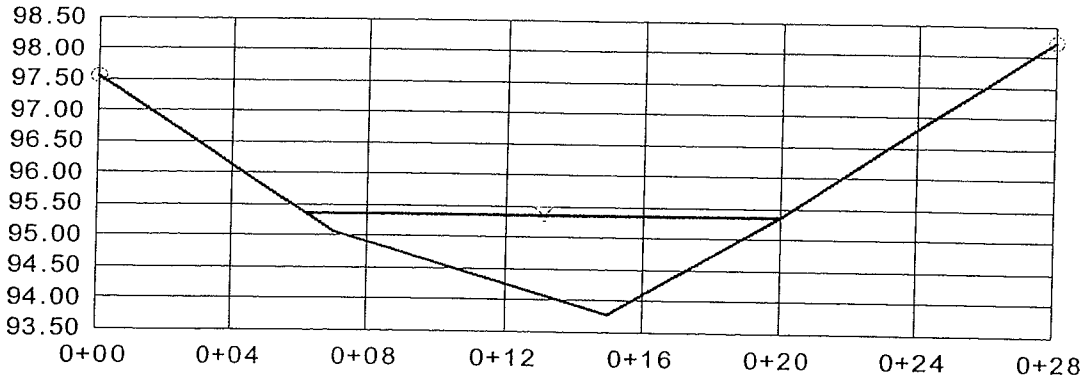
Start Station	End Station	Mannings Coefficient
0+00	0+28	0.045

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	97.54
0+07	95.07
0+15	93.78
0+20	95.35
0+28	98.22

Bankfull Elements

Bankfull Area	11.4 ft^2
Bankfull Width	13.79 ft
Bankfull Depth	1.57 ft



Typical Cross Section

V:2.0
H:1
NTS

- *Data computed using the FlowMaster Computer Program*

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: NGJ *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Swan Creek (W2) - Downstream of Lindsey Road

Benchmark: 100 SW Wingwall of Lindsey Road Bridge

Project Description	
Worksheet	Swan Creek (W2) - Sta. 1+00 Cross Section
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.03
Channel Slope	0.0001 ft/ft
Water Surface Elevation	94.86 ft
Bottom Elevation	92.39 ft
Discharge	11.95 cfs

Roughness Segments

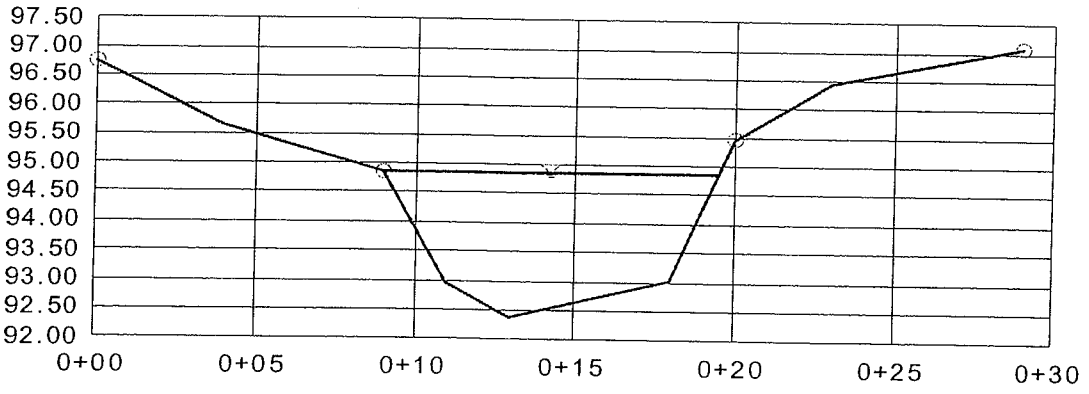
Start Station	End Station	Mannings Coefficient
0+00	0+09	0.06
0+09	0+20	0.03
0+20	0+29	0.035

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	96.73
0+04	95.64
0+09	94.86
0+11	92.96
0+13	92.39
0+18	93.03
0+20	95.47
0+23	96.43
0+29	97.07

Bankfull Elements

Bankfull Area	18.4 ft^2
Bankfull Width	10.5 ft
Bankfull Depth	2.47 ft



Typical Cross Section

V:2.0
H:1
NTS

- *Data computed using the FlowMaster Computer Program*

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: NGJ *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Swan Creek (W3) - Downstream of Palms Road

Benchmark: 100 4" Maple at Station 0+80 - West Side

Project Description	
Worksheet	Swan Creek (W3) - Sta. 0+50 Cross Section
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.035
Channel Slope	0.0003 ft/ft
Water Surface Elevation	96.68 ft
Bottom Elevation	93.6 ft
Discharge	52.36 cfs

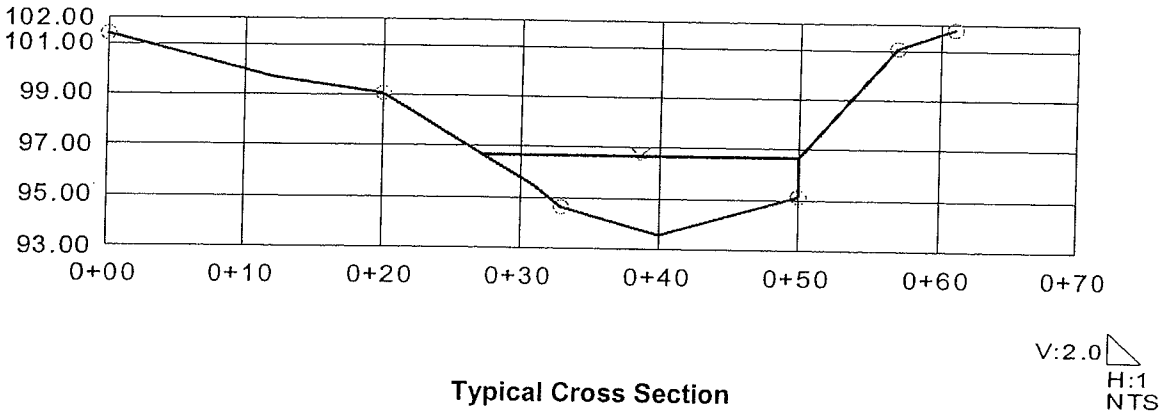
Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	0+20	0.06
0+20	0+33	0.045
0+33	0+50	0.03
0+50	0+57	0.045
0+57	0+61	0.06

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	101.38
0+12	99.69
0+20	99.09
0+31	95.47
0+33	94.64
0+40	93.6
0+50	95.11
0+50	96.68
0+57	101.02
0+61	101.8

Bankfull Elements	
Bankfull Area	46.6 ft^2
Bankfull Width	22.68 ft
Bankfull Depth	3.08 ft



Typical Cross Section

- *Data computed using the FlowMaster Computer Program*

Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: NGJ *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Swan Creek (W6) - Downstream of Short Cut Road

Benchmark: 100 SE Corner of SE Wingwall of Bridge

Project Description	
Worksheet	Swan Creek (W6) Sta. 1+30 Cross Section
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data	
Mannings Coefficient	0.033
Channel Slope	0.00003 ft/ft
Water Surface Elevation	92.8 ft
Bottom Elevation	90.23 ft
Discharge	19.3 cfs

Roughness Segments

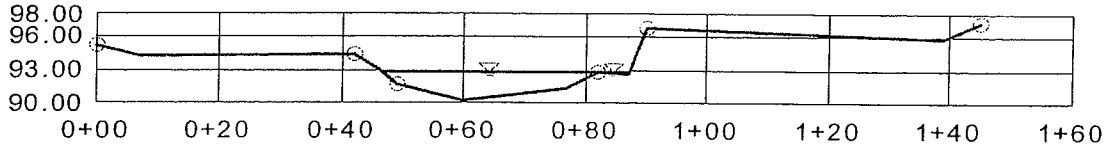
Start Station	End Station	Mannings Coefficient
0+00	0+42	0.06
0+42	0+49	0.045
0+49	0+82	0.03
0+82	0+90	0.045
0+90	1+45	0.06

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	95.14
0+07	94.14
0+42	94.29
0+46	93.05
0+49	91.64
0+60	90.23
0+77	91.3
0+82	92.8
0+87	92.62
0+90	96.72
1+39	95.85
1+45	97.31

Bankfull Elements

Bankfull Area	60.8 ft^2
Bankfull Width	40.6 ft
Bankfull Depth	2.57 ft



Typical Cross Section

V:2.0
H:1
NTS

- *Data computed using the FlowMaster Computer Program*

Appendix 4: Bed Material Analysis

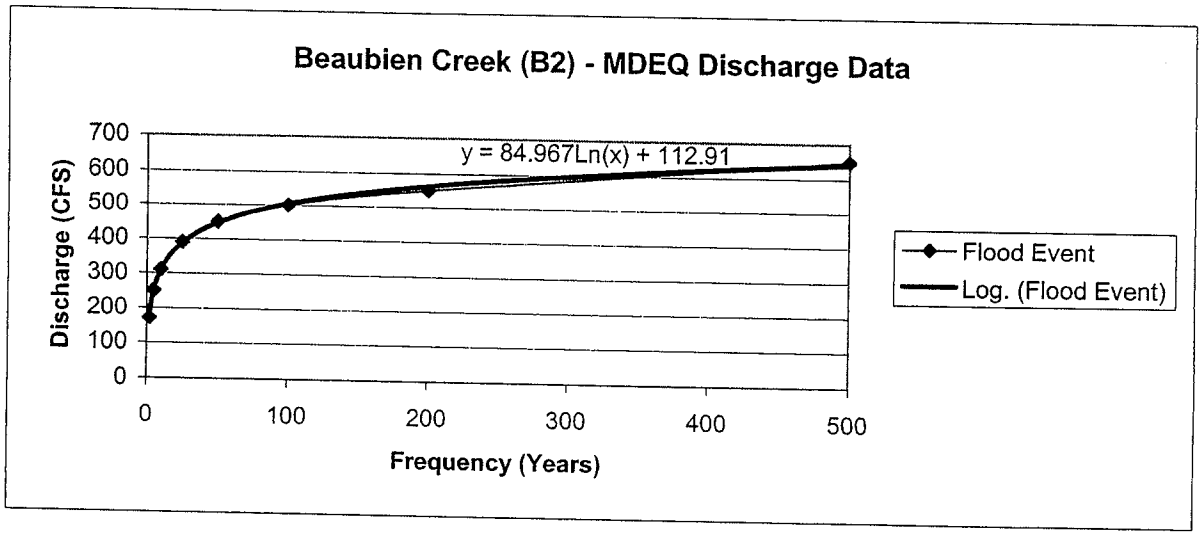
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/14/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Beaubien Creek (B2) - Downstream of Arnold Road

MDEQ Discharge Data

Frequency (Years)	Discharge (CFS)
2	170
5	250
10	310
25	390
50	450
100	500
200	550
500	650



Bankfull Flow Area (ft^2)	32.3
Bankfull Discharge (CFS)	102.77
Frequency (Years)	0.9

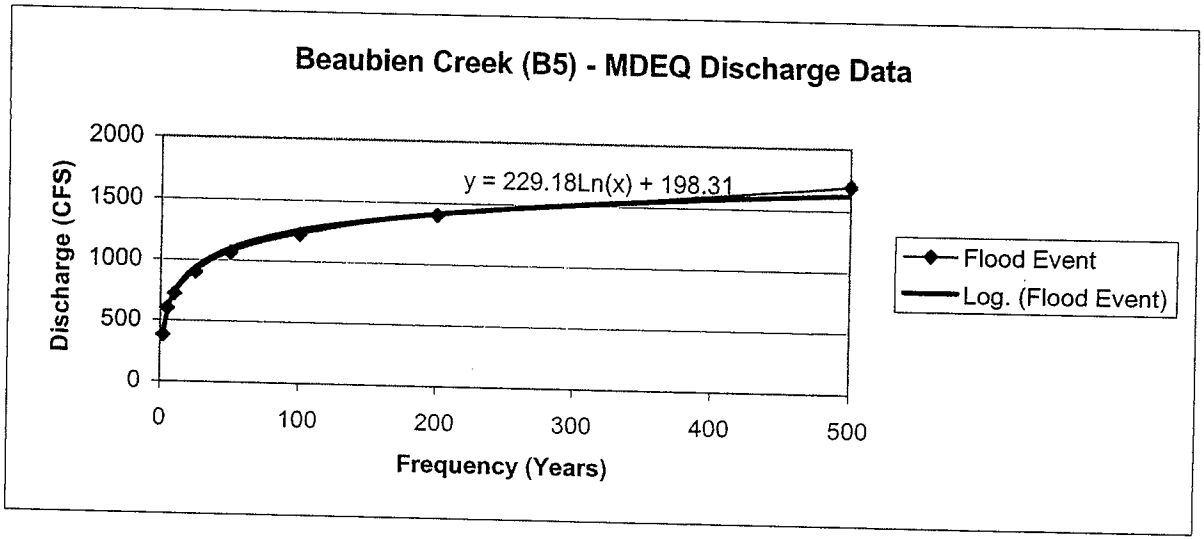
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/14/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Beaubien Creek (B5) - Downstream of Starville Road

MDEQ Discharge Data

Frequency (Years)	Discharge (CFS)
2	380
5	600
10	720
25	900
50	1060
100	1220
200	1400
500	1690



Bankfull Flow Area (ft^2)	44.8
Bankfull Discharge (CFS)	142.32
Frequency (Years)	0.8

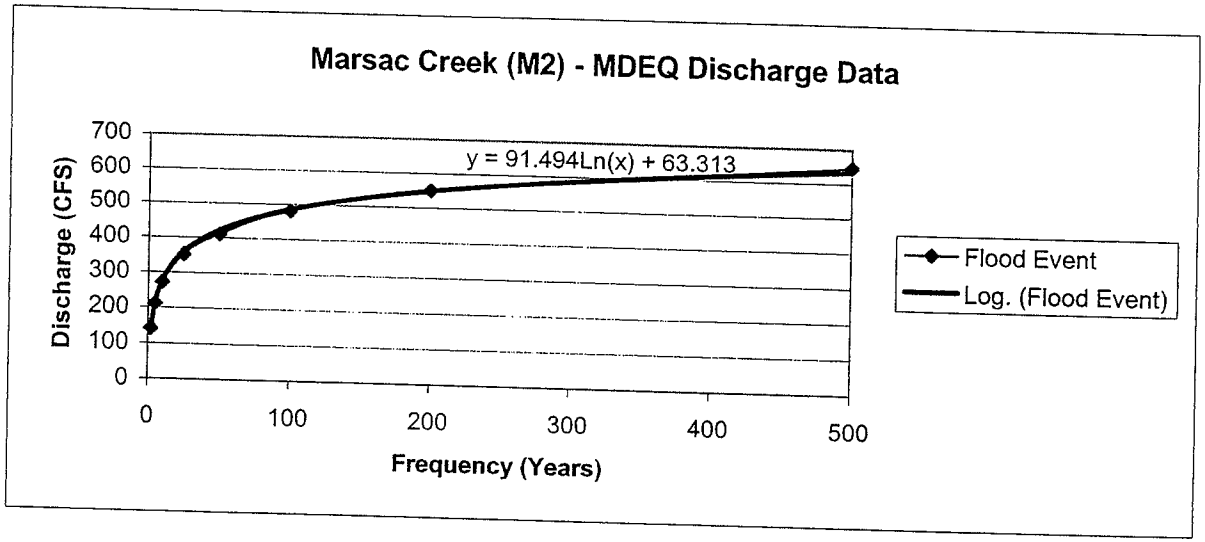
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/14/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M2) - Downstream of Marine City Highway

MDEQ Discharge Data

Frequency (Years)	Discharge (CFS)
2	140
5	210
10	270
25	350
50	410
100	480
200	550
500	645



Bankfull Flow Area (ft^2)	11.5
Bankfull Discharge (CFS)	20.48
Frequency (Years)	0.6

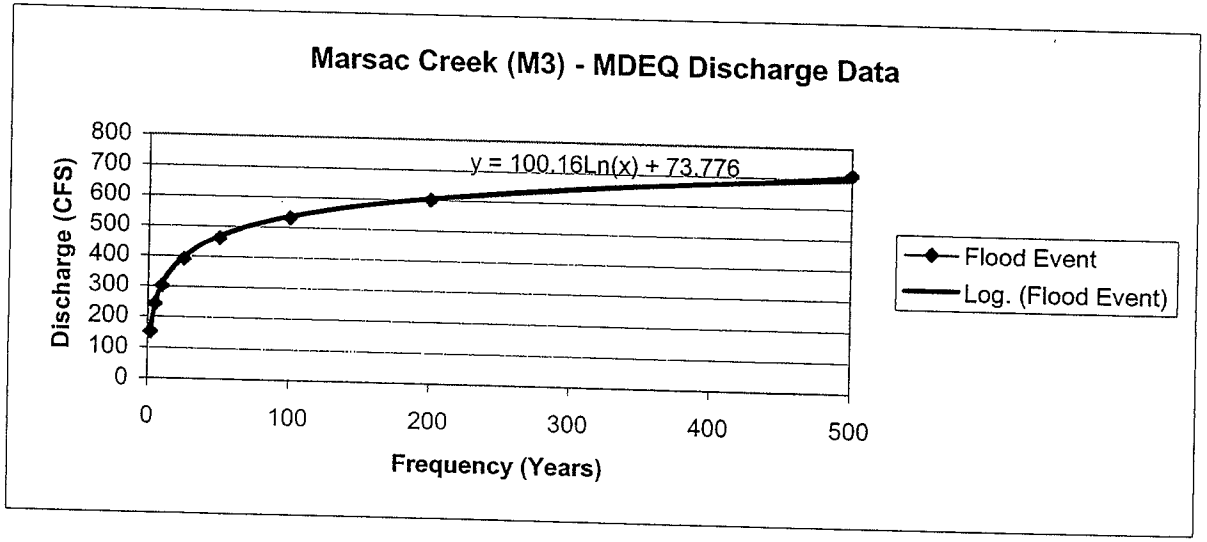
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/14/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M3) - Downstream of Bethuy Road

MDEQ Discharge Data

Frequency (Years)	Discharge (CFS)
2	150
5	240
10	300
25	390
50	460
100	530
200	600
500	710



Bankfull Flow Area (ft^2)	25.3
Bankfull Discharge (CFS)	56.11
Frequency (Years)	0.8

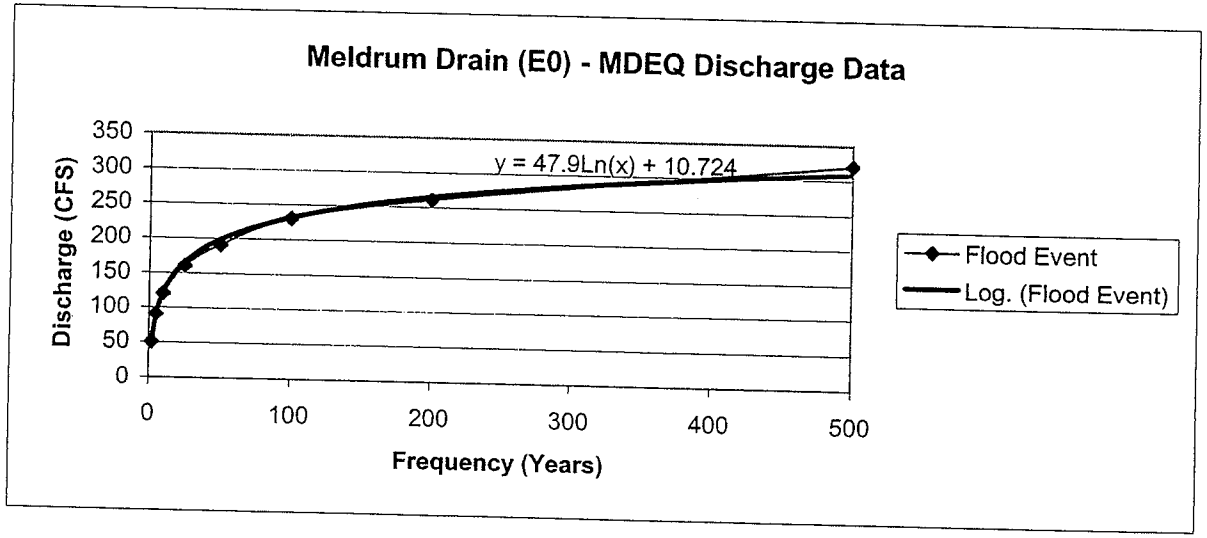
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/14/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Meldrum Drain (E0) - Downstream of Meisner Road

MDEQ Discharge Data

Frequency (Years)	Discharge (CFS)
2	50
5	90
10	120
25	160
50	190
100	230
200	260
500	320



Bankfull Flow Area (ft^2)	12.6
Bankfull Discharge (CFS)	32.14
Frequency (Years)	1.6

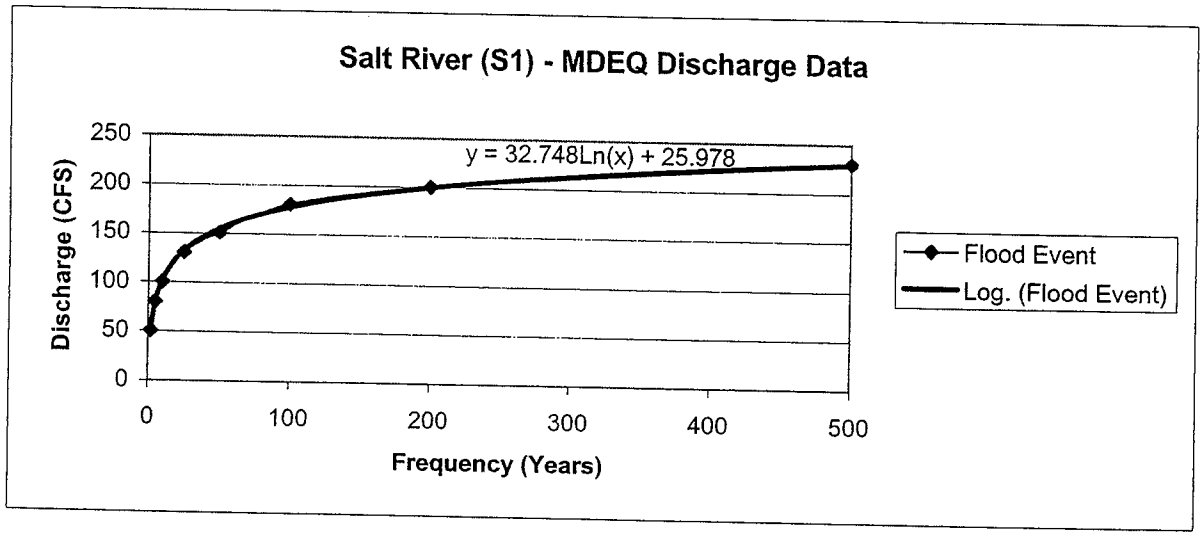
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/14/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Salt River (S1) - Downstream of 30 Mile Road

MDEQ Discharge Data

Frequency (Years)	Discharge (CFS)
2	50
5	80
10	100
25	130
50	150
100	180
200	200
500	230



Bankfull Flow Area (ft^2)	9.7
Bankfull Discharge (CFS)	8.56
Frequency (Years)	0.6

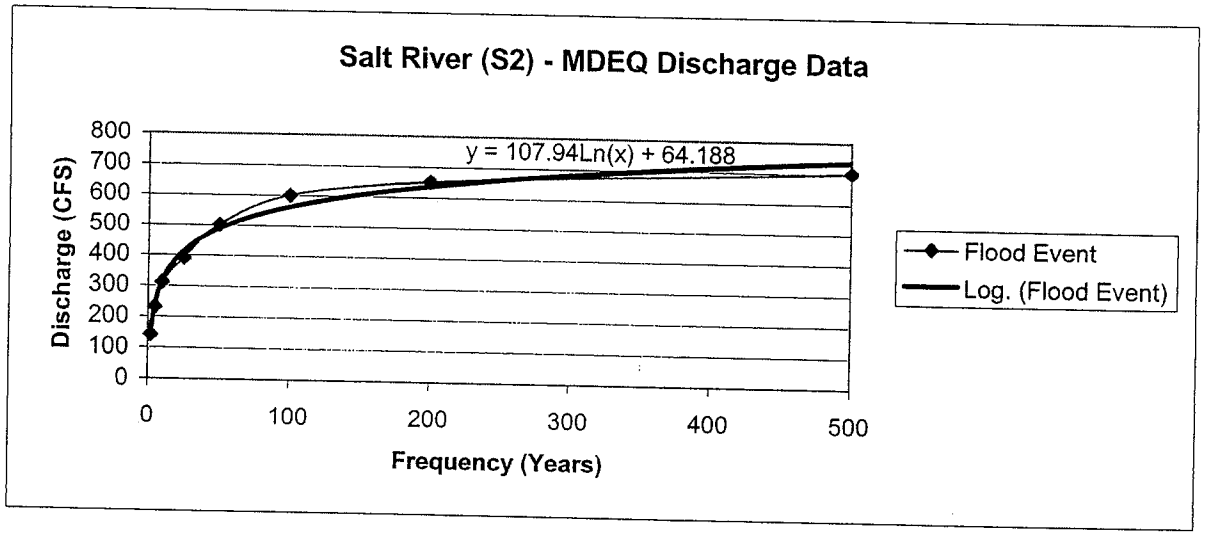
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/14/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Salt River (S2) - Downstream of 29 Mile Road

MDEQ Discharge Data

Frequency (Years)	Discharge (CFS)
2	140
5	230
10	310
25	390
50	500
100	600
200	650
500	700



Bankfull Flow Area (ft^2)	11.3
Bankfull Discharge (CFS)	25.59
Frequency (Years)	0.7

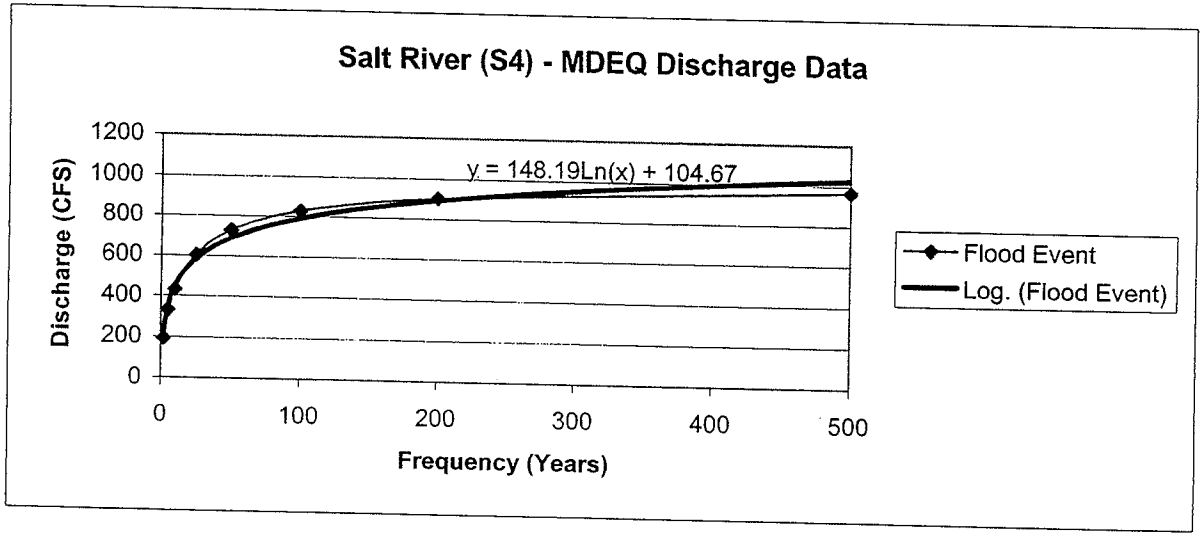
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/14/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Salt River (S4) - Downstream of M-19

MDEQ Discharge Data

Frequency (Years)	Discharge (CFS)
2	190
5	330
10	430
25	600
50	725
100	825
200	900
500	965



Bankfull Flow Area (ft^2)	40.8
Bankfull Discharge (CFS)	23.25
Frequency (Years)	0.6

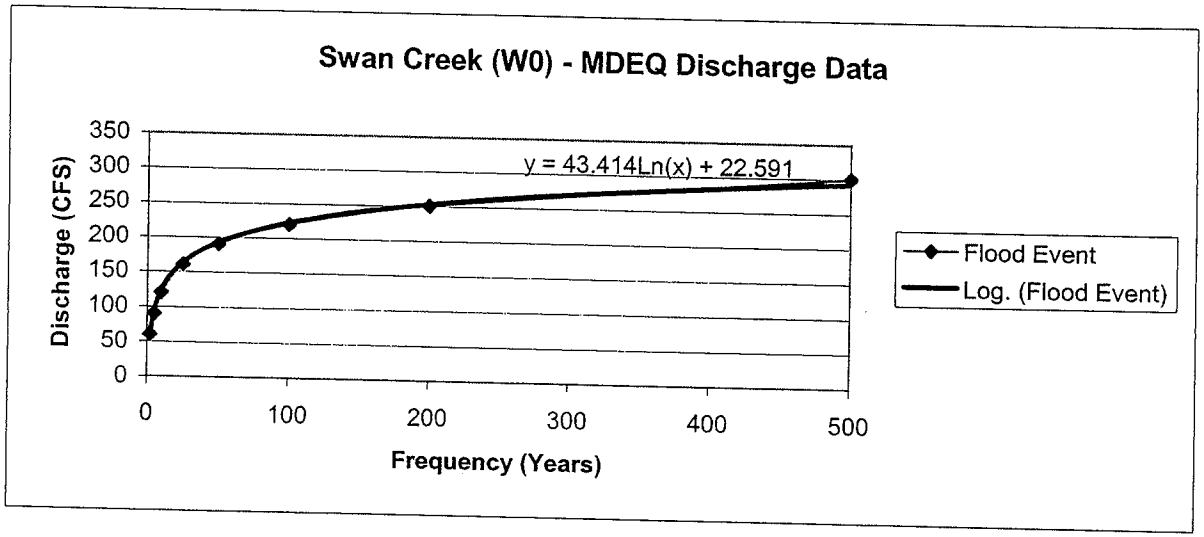
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/14/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Swan Creek (W0) - Downstream of Meldrum Road

MDEQ Discharge Data

Frequency (Years)	Discharge (CFS)
2	60
5	90
10	120
25	160
50	190
100	220
200	250
500	300



Bankfull Flow Area (ft^2)	11.4
Bankfull Discharge (CFS)	17
Frequency (Years)	0.9

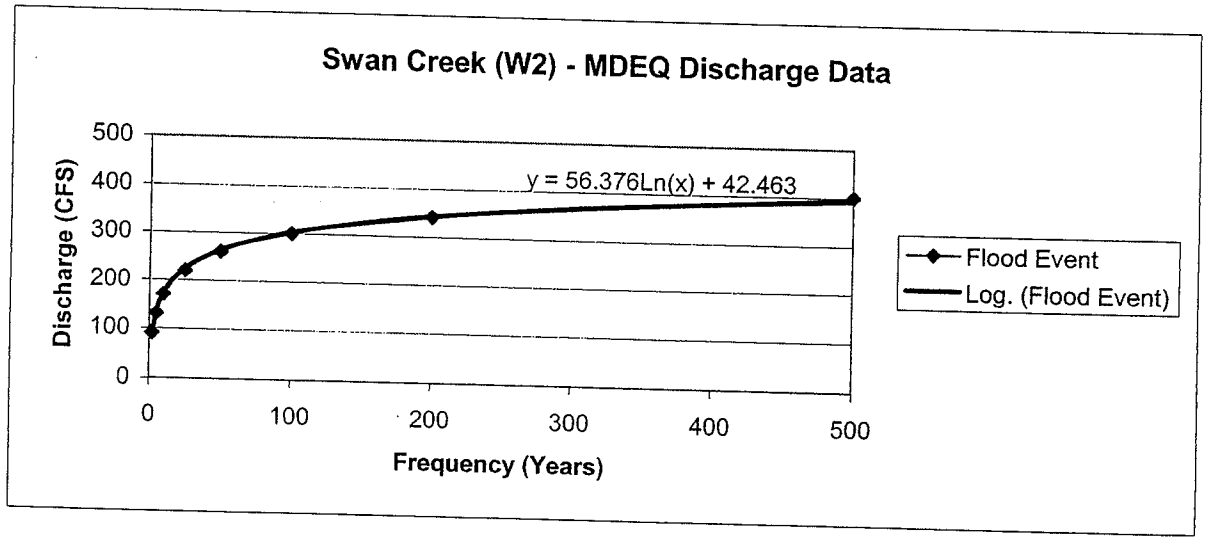
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/14/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Swan Creek (W2) - Downstream of Lindsey Road

MDEQ Discharge Data

Frequency (Years)	Discharge (CFS)
2	90
5	130
10	170
25	220
50	260
100	300
200	340
500	400



Bankfull Flow Area (ft^2)	18.4
Bankfull Discharge (CFS)	11.95
Frequency (Years)	0.6

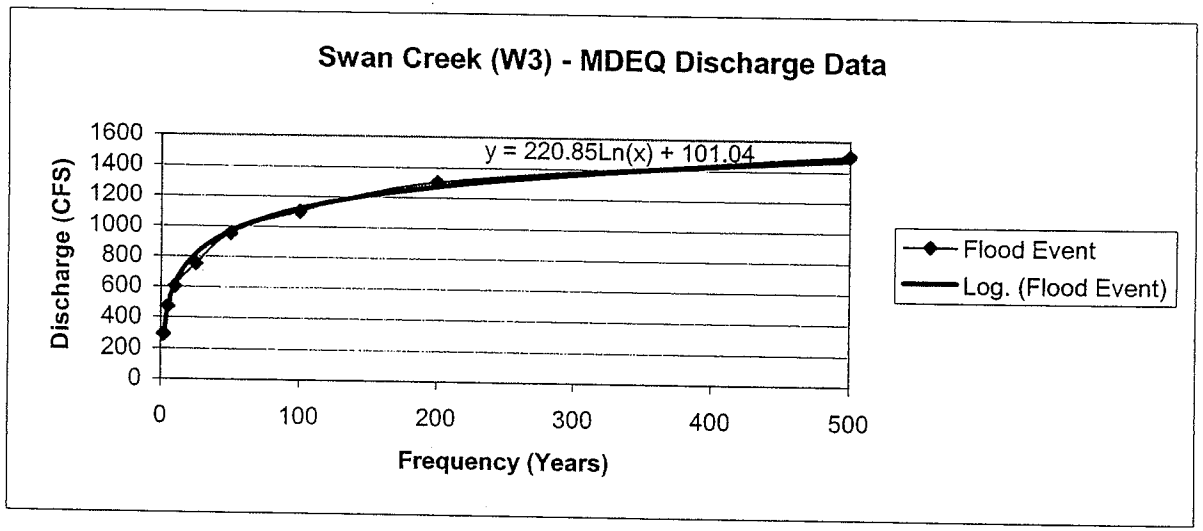
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/14/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

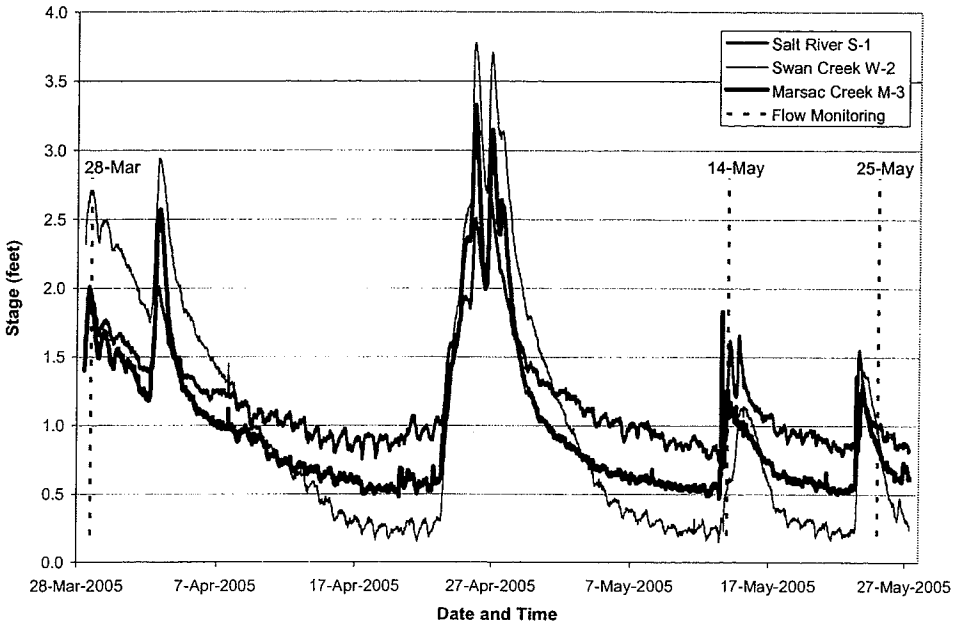
Reference Reach: Swan Creek (W3) - Downstream of Palms Road

MDEQ Discharge Data

Frequency (Years)	Discharge (CFS)
2	290
5	470
10	600
25	750
50	950
100	1100
200	1300
500	1500



Bankfull Flow Area (ft^2)	46.6
Bankfull Discharge (CFS)	52.36
Frequency (Years)	0.8


Salt River S-1
Swan Creek W-2
Marsac Creek M-3
Flow Monitoring
28-Mar
14-May
25-May
Stage (feet)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
28-Mar-2005
7-Apr-2005
17-Apr-2005
27-Apr-2005
7-May-2005
17-May-2005
27-May-2005
Date and Time

Appendix 5: Rosgen Level II Stream Type Classification

Project: Anchor Bay Watershed
No: G04211
Survey Date: 4/1/2005
Engineer: DF2

Template Title: Bed Material Analysis

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach ID	Pebble Count Data		Andy's 1x1=1 Rule		Greater Material Size	Explanation of Discrepancy
	D_{50} (Inches)	Material	D_{50} (Inches)	Material		
T1	0.009	Fine Sand	0.558	Medium Gravel	Andy's Rule	Pebble Count is consistent with Soil Type
T2	0.039	Coarse Sand	0.092	Very Fine Gravel	Andy's Rule	Pebble Count is consistent with Soil Type
M1	0.017	Medium Sand	0.158	Fine Gravel	Andy's Rule	
W0	0.001	Silt / Clay	0.424	Medium Gravel	Andy's Rule	Pebble Count is consistent with Soil Type
S1	0.002	Silt / Clay	0.202	Fine Gravel	Andy's Rule	Pebble Count is consistent with Soil Type
S2	0.466	Medium Gravel	0.489	Medium Gravel		
M2	0.027	Coarse Sand	0.238	Fine Gravel	Andy's Rule	
E0	0.166	Fine Gravel	0.355	Medium Gravel	Andy's Rule	
W2	0.002	Silt / Clay	0.025	Coarse Sand	Andy's Rule	Pebble Count is consistent with Soil Type
B2	NA	NA	NA	NA		
M3	0.380	Medium Gravel	0.803	Coarse Gravel	Andy's Rule	Unnatural channel lining (broken concrete portions)
S4	NA	NA	NA	NA		
B5	NA	NA	NA	NA		
W3	0.002	Silt / Clay	0.092	Very Fine Gravel	Andy's Rule	Pebble Count is consistent with Soil Type
W6	NA	NA	NA	NA		

Note:

- The bed material characterized by the **Wolman Pebble Count** is, for the most part, consistent with the prevailing soil type along the reference reach.
- The diameter of **Andy's 1x1=1 Rule** was calculated using the method prescribed by Dr. Andy Ward of The Ohio State University, in which, the diameter (D_{50}) of the bed material (inches) is equal to the product of the bankfull depth of flow (feet) and bed slope (%), determined from field measurements.
- In general, the theoretical diameter calculated using **Andy's 1x1=1 Rule** is greater than the actual diameter of the bed material as determined by the **Wolman Pebble Count.** This discrepancy is more likely due to the prevailing fine grain soil type of the waterway rather than an error in measuring the bankfull depth or bed slope.

Project: Anchor Bay Watershed
No: G04211
Survey Date: 38443
Engineer: DF2

Template Title: General Soil Types

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach ID	Soil Symbol	Soil Name	Hydrologic Soil Group	Soil Description
T1	Wda	Wainola-Deford Fine Sands	SM, SP-SM	Fine Sand
T2	Ld	Lamson Fine Sandy Loam	SM, ML-CL	Fine Sandy Loam, Layers of Silt Loam, Very Fine Sand
M1	LhA	Latty Complex	ML-CL, CH	Silty Clay Loam, Clay
W0	LhA	Latty Complex	ML-CL, CH	Silty Clay Loam, Clay
S1	Hy	Hoytville Clay Loam	CH, CL, MH	Silty Clay Loam, Clay
S2	Sh	Shoals Loam	CL, ML, CL-ML	Loam, Silty Loam
M2	LhA	Latty Complex	ML-CL, CH	Silty Clay Loam, Clay
E0	LhA	Latty Complex	ML-CL, CH	Silty Clay Loam, Clay
W2	LhA	Latty Complex	ML-CL, CH	Silty Clay Loam, Clay
B2	Le	Latty Silty Clay Loam	ML-CL, CH	Silty Clay Loam, Clay
M3	AtA	Allendale-Lenawee-Toledo Complex	SM, SP-SM, CH	Loamy Fine Sand, Fine Sand, Clay
S4	Sc	Saranac Clay Loam	CL, CH, SM, SP-SM	Clay, Silty Clay
B5	To	Toledo Silty Clay Loam	CL, CH, SM	Silty Clay Loam, Clay, Clay Loam, Fine Sandy Loam
W3	Au	Alluvial Land		Stratified Mineral Material of Sand to Silty Clay Texture
W6	Au	Alluvial Land		Stratified Mineral Material of Sand to Silty Clay Texture

Source: Macomb and St. Clair County Soil Surveys

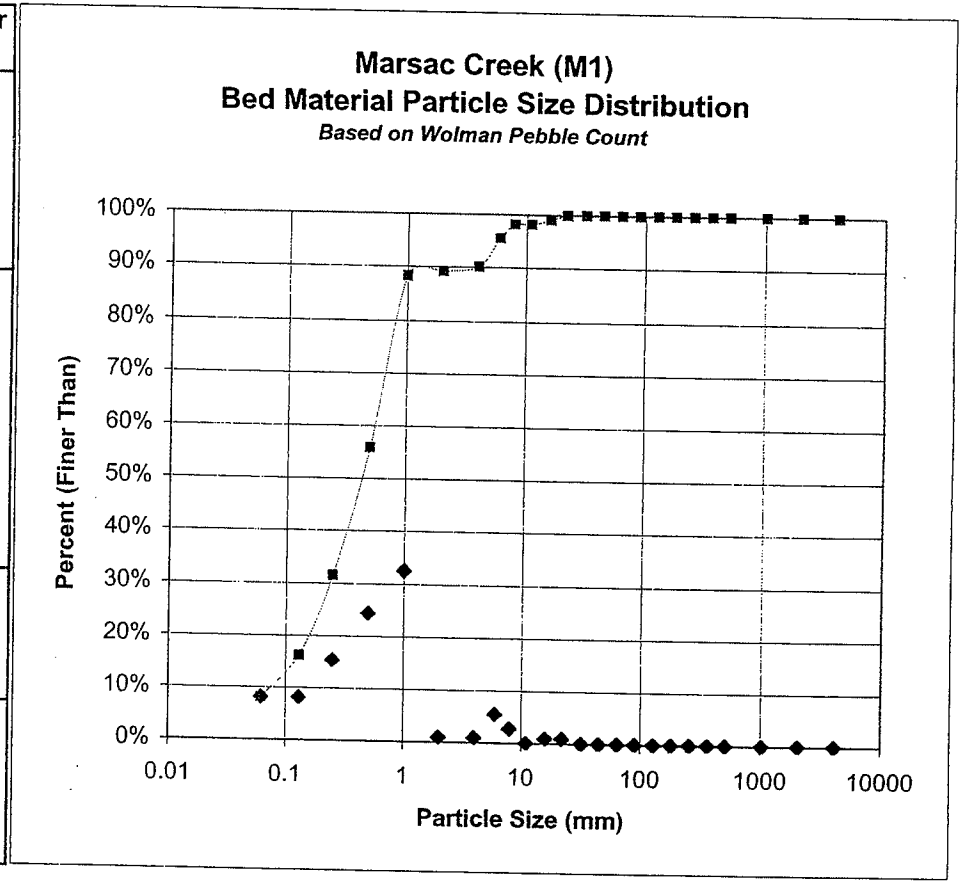
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: JWF *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M1) - Downstream of Springborn Road

Pebble Count Data

Material	Size Range (mm)		Count	% Count	Total Finer	% Finer Than
Silt / Clay	0	0.062	9	8%	9	8%
Very Fine Sand	0.062	0.13	9	8%	18	16%
Fine Sand	0.13	0.25	17	15%	35	32%
Medium Sand	0.25	0.5	27	24%	62	56%
Coarse Sand	0.5	1	36	32%	98	88%
Very Coarse Sand	1	2	1	1%	99	89%
Very Fine Gravel	2	4	1	1%	100	90%
Fine Gravel	4	6	6	5%	106	95%
Fine Gravel	6	8	3	3%	109	98%
Medium Gravel	8	11		0%	109	98%
Medium Gravel	11	16	1	1%	110	99%
Coarse Gravel	16	22	1	1%	111	100%
Coarse Gravel	22	32		0%	111	100%
Very Coarse Gravel	32	45		0%	111	100%
Very Coarse Gravel	45	64		0%	111	100%
Small Cobble	64	90		0%	111	100%
Medium Cobble	90	128		0%	111	100%
Large Cobble	128	180		0%	111	100%
Very Large Cobble	180	256		0%	111	100%
Small Boulder	256	362		0%	111	100%
Small Boulder	362	512		0%	111	100%
Medium Boulder	512	1024		0%	111	100%
Large Boulder	1024	2048		0%	111	100%
Very Large Boulder	2048	4096		0%	111	100%
		Total	111	100%		



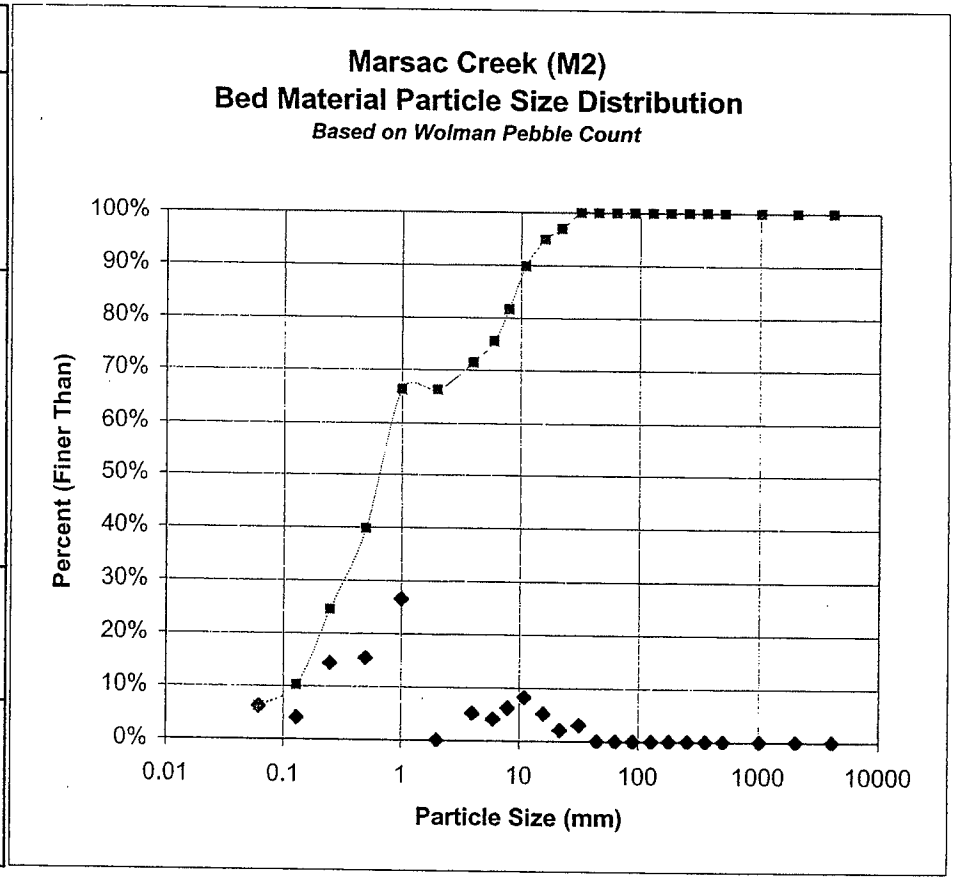
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: JWF *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M2) - Downstream of Marine City Highway

Pebble Count Data

Material	Size Range (mm)		Count	% Count	Total Finer	% Finer Than
Silt / Clay	0	0.062	6	6%	6	6%
Very Fine Sand	0.062	0.13	4	4%	10	10%
Fine Sand	0.13	0.25	14	14%	24	24%
Medium Sand	0.25	0.5	15	15%	39	40%
Coarse Sand	0.5	1	26	27%	65	66%
Very Coarse Sand	1	2		0%	65	66%
Very Fine Gravel	2	4	5	5%	70	71%
Fine Gravel	4	6	4	4%	74	76%
Fine Gravel	6	8	6	6%	80	82%
Medium Gravel	8	11	8	8%	88	90%
Medium Gravel	11	16	5	5%	93	95%
Coarse Gravel	16	22	2	2%	95	97%
Coarse Gravel	22	32	3	3%	98	100%
Very Coarse Gravel	32	45		0%	98	100%
Very Coarse Gravel	45	64		0%	98	100%
Small Cobble	64	90		0%	98	100%
Medium Cobble	90	128		0%	98	100%
Large Cobble	128	180		0%	98	100%
Very Large Cobble	180	256		0%	98	100%
Small Boulder	256	362		0%	98	100%
Small Boulder	362	512		0%	98	100%
Medium Boulder	512	1024		0%	98	100%
Large Boulder	1024	2048		0%	98	100%
Very Large Boulder	2048	4096		0%	98	100%
		Total	98	100%		



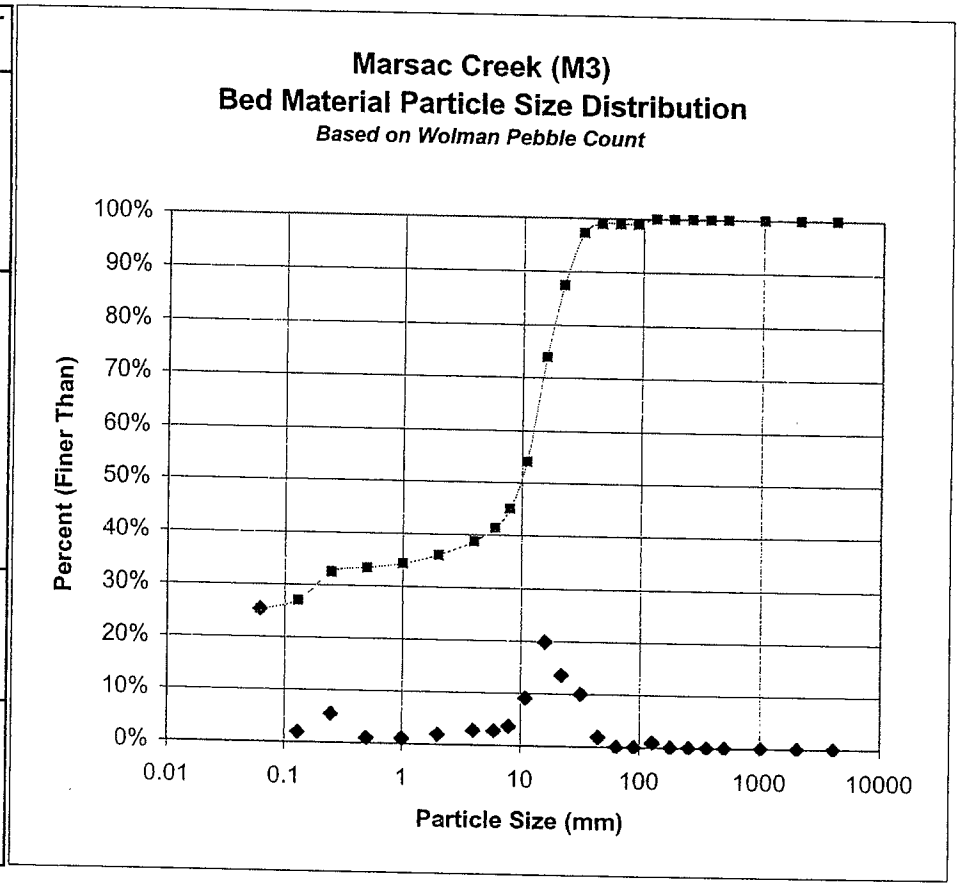
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/8/2004
Engineer: DF2 *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M3) - Downstream of Bethuy Road

Pebble Count Data

Material	Size Range (mm)		Count	% Count	Total Finer	% Finer Than
Silt / Clay	0	0.062	28	25%	28	25%
Very Fine Sand	0.062	0.13	2	2%	30	27%
Fine Sand	0.13	0.25	6	5%	36	32%
Medium Sand	0.25	0.5	1	1%	37	33%
Coarse Sand	0.5	1	1	1%	38	34%
Very Coarse Sand	1	2	2	2%	40	36%
Very Fine Gravel	2	4	3	3%	43	39%
Fine Gravel	4	6	3	3%	46	41%
Fine Gravel	6	8	4	4%	50	45%
Medium Gravel	8	11	10	9%	60	54%
Medium Gravel	11	16	22	20%	82	74%
Coarse Gravel	16	22	15	14%	97	87%
Coarse Gravel	22	32	11	10%	108	97%
Very Coarse Gravel	32	45	2	2%	110	99%
Very Coarse Gravel	45	64		0%	110	99%
Small Cobble	64	90		0%	110	99%
Medium Cobble	90	128	1	1%	111	100%
Large Cobble	128	180		0%	111	100%
Very Large Cobble	180	256		0%	111	100%
Small Boulder	256	362		0%	111	100%
Small Boulder	362	512		0%	111	100%
Medium Boulder	512	1024		0%	111	100%
Large Boulder	1024	2048		0%	111	100%
Very Large Boulder	2048	4096		0%	111	100%
		Total	111	100%		



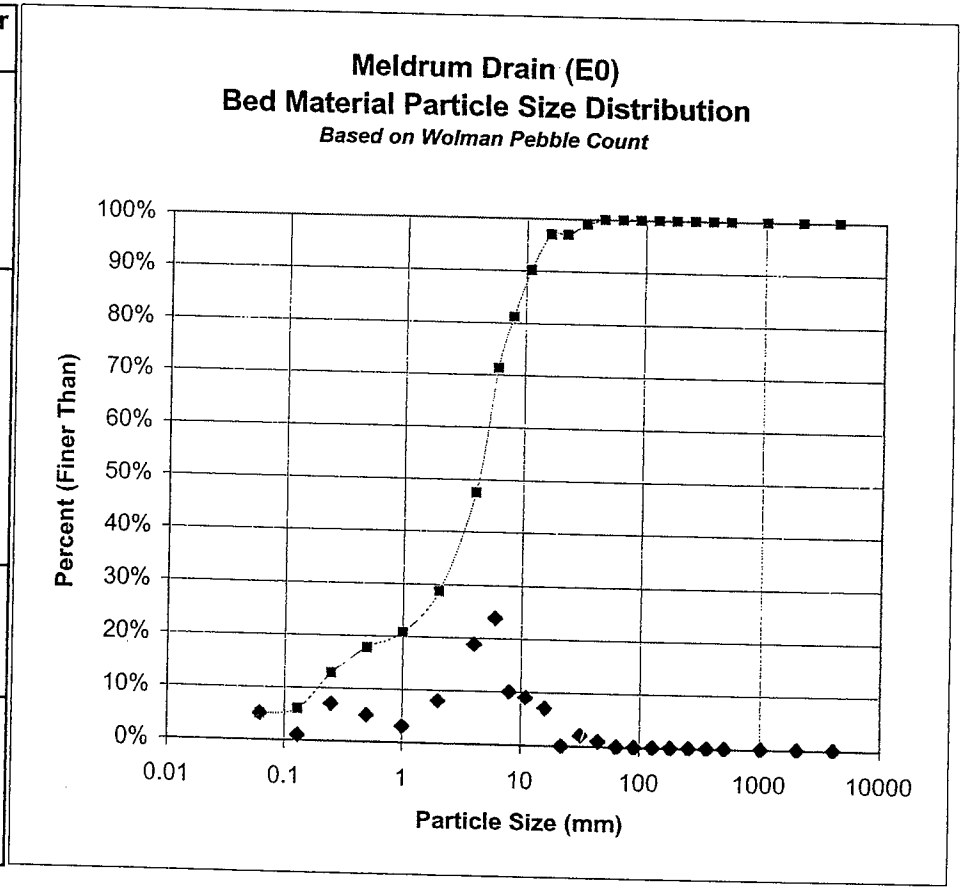
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: DF2 *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Meldrum Drain (E0) - Downstream of Meisner Road

Pebble Count Data

Material	Size Range (mm)		Count	% Count	Total Finer	% Finer Than
Silt / Clay	0	0.062	5	5%	5	5%
Very Fine Sand	0.062	0.13	1	1%	6	6%
Fine Sand	0.13	0.25	7	7%	13	13%
Medium Sand	0.25	0.5	5	5%	18	18%
Coarse Sand	0.5	1	3	3%	21	21%
Very Coarse Sand	1	2	8	8%	29	29%
Very Fine Gravel	2	4	19	19%	48	48%
Fine Gravel	4	6	24	24%	72	71%
Fine Gravel	6	8	10	10%	82	81%
Medium Gravel	8	11	9	9%	91	90%
Medium Gravel	11	16	7	7%	98	97%
Coarse Gravel	16	22		0%	98	97%
Coarse Gravel	22	32	2	2%	100	99%
Very Coarse Gravel	32	45	1	1%	101	100%
Very Coarse Gravel	45	64		0%	101	100%
Small Cobble	64	90		0%	101	100%
Medium Cobble	90	128		0%	101	100%
Large Cobble	128	180		0%	101	100%
Very Large Cobble	180	256		0%	101	100%
Small Boulder	256	362		0%	101	100%
Small Boulder	362	512		0%	101	100%
Medium Boulder	512	1024		0%	101	100%
Large Boulder	1024	2048		0%	101	100%
Very Large Boulder	2048	4096		0%	101	100%
		Total	101	100%		



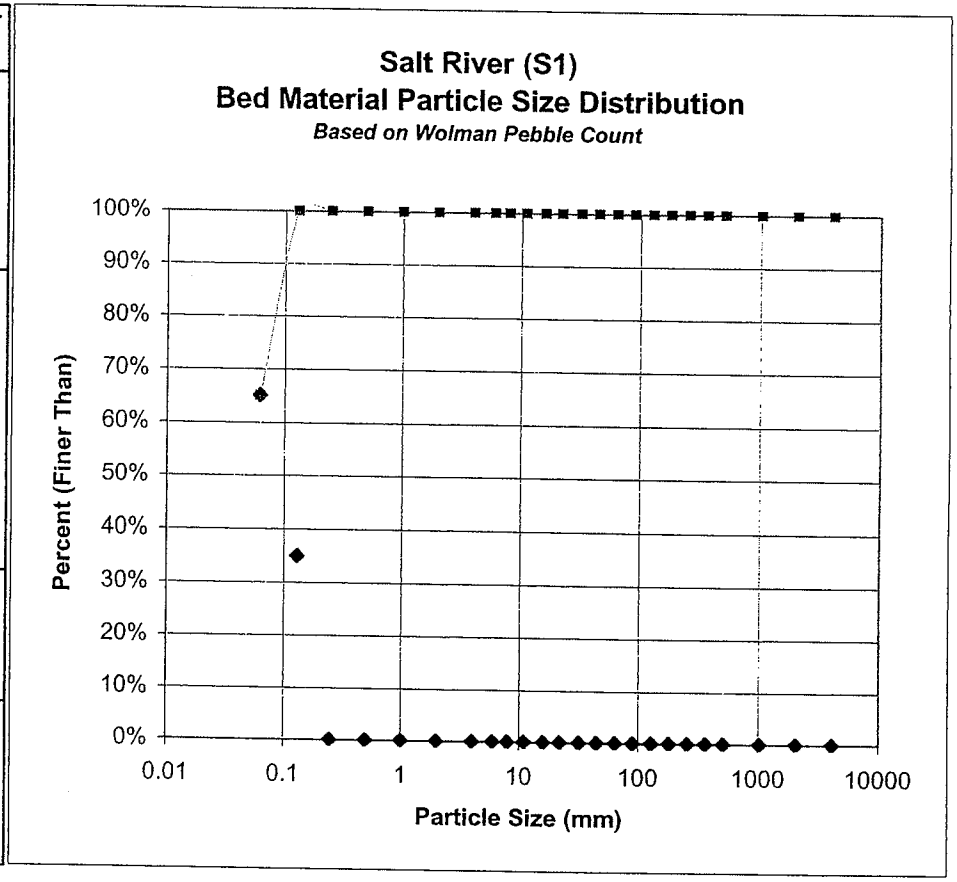
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/10/2004
Engineer: KEE *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Salt River (S1) - Downstream of 30 Mile Road

Pebble Count Data

Material	Size Range (mm)		Count	% Count	Total Finer	% Finer Than
Silt / Clay	0	0.062	65	65%	65	65%
Very Fine Sand	0.062	0.13	35	35%	100	100%
Fine Sand	0.13	0.25		0%	100	100%
Medium Sand	0.25	0.5		0%	100	100%
Coarse Sand	0.5	1		0%	100	100%
Very Coarse Sand	1	2		0%	100	100%
Very Fine Gravel	2	4		0%	100	100%
Fine Gravel	4	6		0%	100	100%
Fine Gravel	6	8		0%	100	100%
Medium Gravel	8	11		0%	100	100%
Medium Gravel	11	16		0%	100	100%
Coarse Gravel	16	22		0%	100	100%
Coarse Gravel	22	32		0%	100	100%
Very Coarse Gravel	32	45		0%	100	100%
Very Coarse Gravel	45	64		0%	100	100%
Small Cobble	64	90		0%	100	100%
Medium Cobble	90	128		0%	100	100%
Large Cobble	128	180		0%	100	100%
Very Large Cobble	180	256		0%	100	100%
Small Boulder	256	362		0%	100	100%
Small Boulder	362	512		0%	100	100%
Medium Boulder	512	1024		0%	100	100%
Large Boulder	1024	2048		0%	100	100%
Very Large Boulder	2048	4096		0%	100	100%
		Total	100	100%		



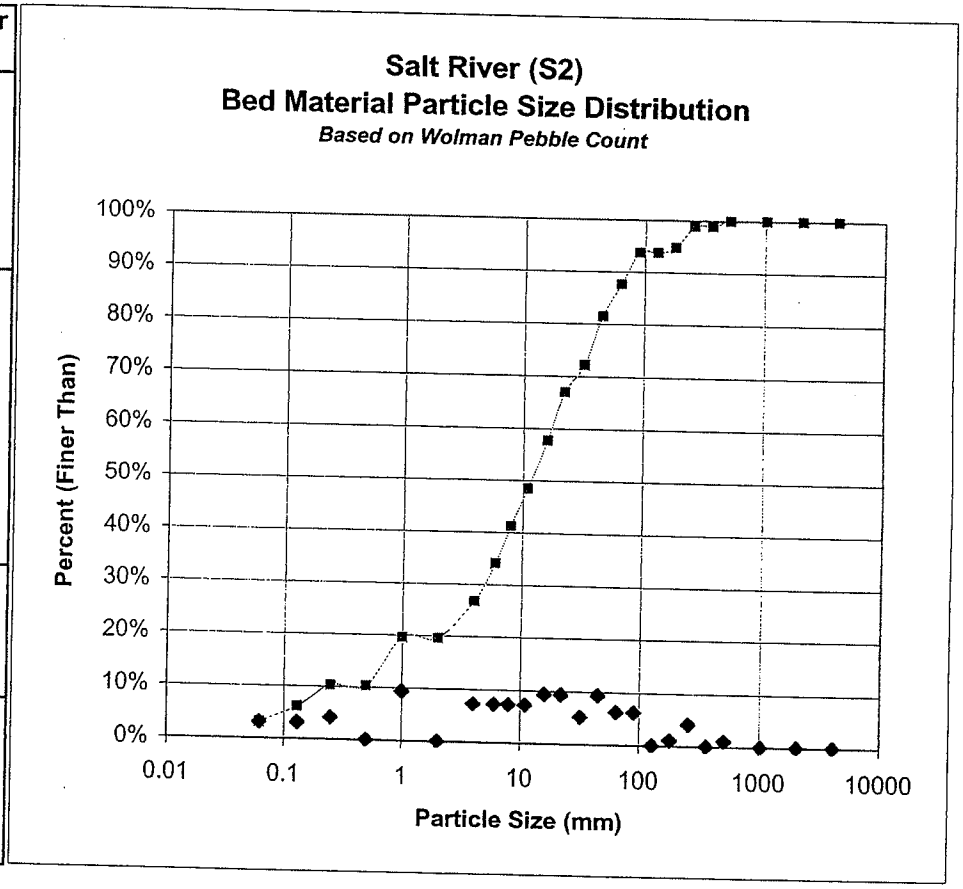
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: JWF *Spreadsheet Computed by DF2*

Reference Reach: Salt River (S2) - Downstream of 29 Mile Road

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Pebble Count Data

Material	Size Range (mm)		Count	% Count	Total Finer	% Finer Than
Silt / Clay	0	0.062	3	3%	3	3%
Very Fine Sand	0.062	0.13	3	3%	6	6%
Fine Sand	0.13	0.25	4	4%	10	10%
Medium Sand	0.25	0.5		0%	10	10%
Coarse Sand	0.5	1	9	9%	19	20%
Very Coarse Sand	1	2		0%	19	20%
Very Fine Gravel	2	4	7	7%	26	27%
Fine Gravel	4	6	7	7%	33	34%
Fine Gravel	6	8	7	7%	40	41%
Medium Gravel	8	11	7	7%	47	48%
Medium Gravel	11	16	9	9%	56	58%
Coarse Gravel	16	22	9	9%	65	67%
Coarse Gravel	22	32	5	5%	70	72%
Very Coarse Gravel	32	45	9	9%	79	81%
Very Coarse Gravel	45	64	6	6%	85	88%
Small Cobble	64	90	6	6%	91	94%
Medium Cobble	90	128		0%	91	94%
Large Cobble	128	180	1	1%	92	95%
Very Large Cobble	180	256	4	4%	96	99%
Small Boulder	256	362		0%	96	99%
Small Boulder	362	512	1	1%	97	100%
Medium Boulder	512	1024		0%	97	100%
Large Boulder	1024	2048		0%	97	100%
Very Large Boulder	2048	4096		0%	97	100%
		Total	97	100%		



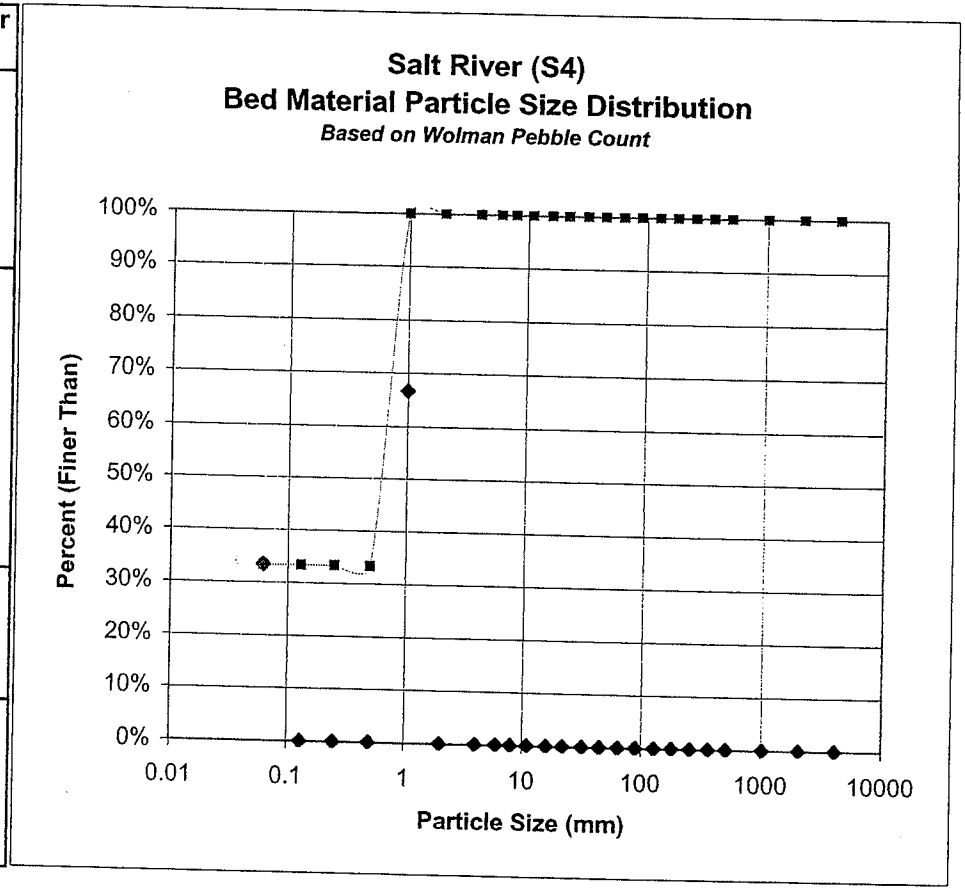
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: JWF *Spreadsheet Computed by DF2*

Reference Reach: Salt River (S4) - Downstream of M-19

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Pebble Count Data

Material	Size Range (mm)		Count	% Count	Total Finer	% Finer Than
Silt / Clay	0	0.062	100	33%	100	33%
Very Fine Sand	0.062	0.13		0%	100	33%
Fine Sand	0.13	0.25		0%	100	33%
Medium Sand	0.25	0.5		0%	100	33%
Coarse Sand	0.5	1	200	67%	300	100%
Very Coarse Sand	1	2		0%	300	100%
Very Fine Gravel	2	4		0%	300	100%
Fine Gravel	4	6		0%	300	100%
Fine Gravel	6	8		0%	300	100%
Medium Gravel	8	11		0%	300	100%
Medium Gravel	11	16		0%	300	100%
Coarse Gravel	16	22		0%	300	100%
Coarse Gravel	22	32		0%	300	100%
Very Coarse Gravel	32	45		0%	300	100%
Very Coarse Gravel	45	64		0%	300	100%
Small Cobble	64	90		0%	300	100%
Medium Cobble	90	128		0%	300	100%
Large Cobble	128	180		0%	300	100%
Very Large Cobble	180	256		0%	300	100%
Small Boulder	256	362		0%	300	100%
Small Boulder	362	512		0%	300	100%
Medium Boulder	512	1024		0%	300	100%
Large Boulder	1024	2048		0%	300	100%
Very Large Boulder	2048	4096		0%	300	100%
		Total	300	100%		



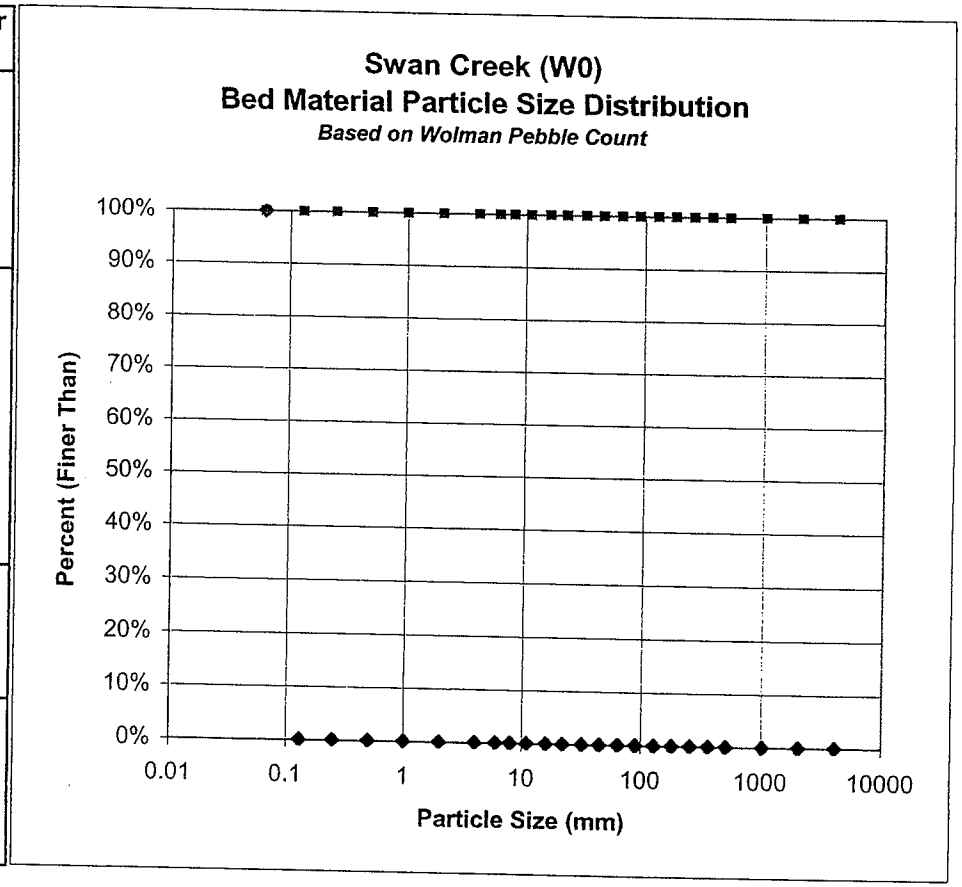
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: KEE *Spreadsheet Computed by DF2*

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Swan Creek (W0) - Downstream of Meldrum Road

Pebble Count Data

Material	Size Range (mm)		Count	% Count	Total Finer	% Finer Than
Silt / Clay	0	0.062	100	100%	100	100%
Very Fine Sand	0.062	0.13		0%	100	100%
Fine Sand	0.13	0.25		0%	100	100%
Medium Sand	0.25	0.5		0%	100	100%
Coarse Sand	0.5	1		0%	100	100%
Very Coarse Sand	1	2		0%	100	100%
Very Fine Gravel	2	4		0%	100	100%
Fine Gravel	4	6		0%	100	100%
Fine Gravel	6	8		0%	100	100%
Medium Gravel	8	11		0%	100	100%
Medium Gravel	11	16		0%	100	100%
Coarse Gravel	16	22		0%	100	100%
Coarse Gravel	22	32		0%	100	100%
Very Coarse Gravel	32	45		0%	100	100%
Very Coarse Gravel	45	64		0%	100	100%
Small Cobble	64	90		0%	100	100%
Medium Cobble	90	128		0%	100	100%
Large Cobble	128	180		0%	100	100%
Very Large Cobble	180	256		0%	100	100%
Small Boulder	256	362		0%	100	100%
Small Boulder	362	512		0%	100	100%
Medium Boulder	512	1024		0%	100	100%
Large Boulder	1024	2048		0%	100	100%
Very Large Boulder	2048	4096		0%	100	100%
		Total	100	100%		



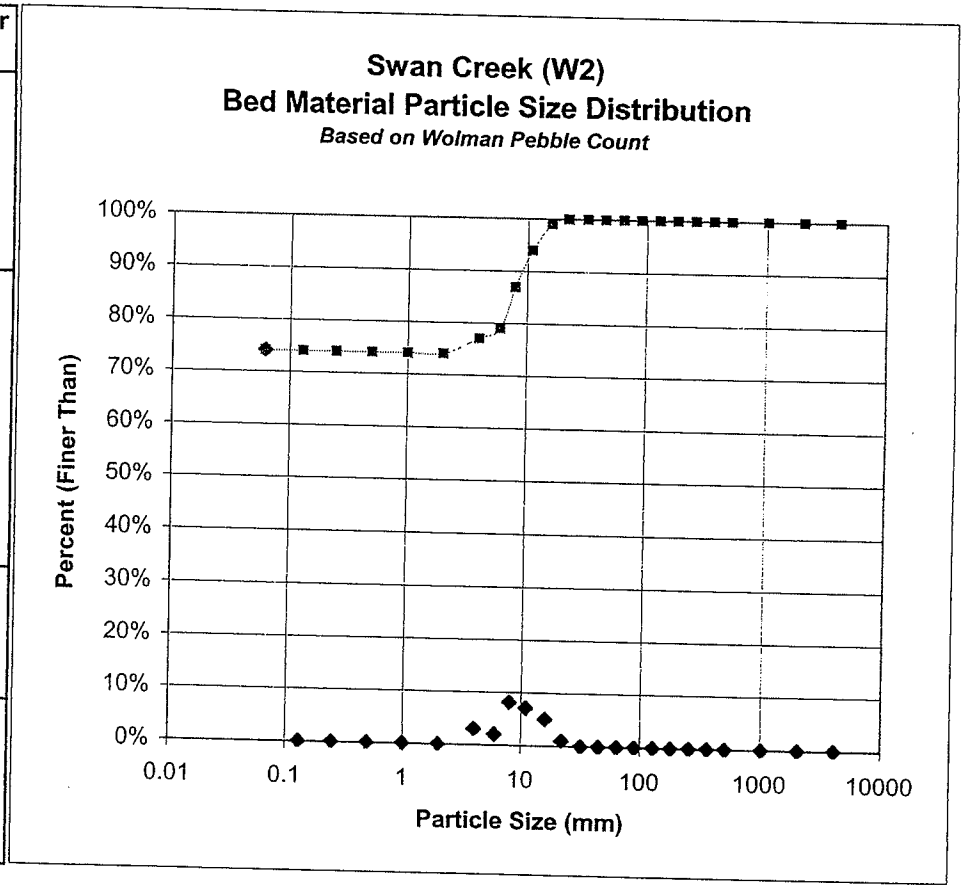
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: NGJ *Spreadsheet Computed by DF2*

Reference Reach: Swan Creek (W2) - Downstream of Lindsey Road

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Pebble Count Data

Material	Size Range (mm)		Count	% Count	Total Finer	% Finer Than
Silt / Clay	0	0.062	74	74%	74	74%
Very Fine Sand	0.062	0.13		0%	74	74%
Fine Sand	0.13	0.25		0%	74	74%
Medium Sand	0.25	0.5		0%	74	74%
Coarse Sand	0.5	1		0%	74	74%
Very Coarse Sand	1	2		0%	74	74%
Very Fine Gravel	2	4	3	3%	77	77%
Fine Gravel	4	6	2	2%	79	79%
Fine Gravel	6	8	8	8%	87	87%
Medium Gravel	8	11	7	7%	94	94%
Medium Gravel	11	16	5	5%	99	99%
Coarse Gravel	16	22	1	1%	100	100%
Coarse Gravel	22	32		0%	100	100%
Very Coarse Gravel	32	45		0%	100	100%
Very Coarse Gravel	45	64		0%	100	100%
Small Cobble	64	90		0%	100	100%
Medium Cobble	90	128		0%	100	100%
Large Cobble	128	180		0%	100	100%
Very Large Cobble	180	256		0%	100	100%
Small Boulder	256	362		0%	100	100%
Small Boulder	362	512		0%	100	100%
Medium Boulder	512	1024		0%	100	100%
Large Boulder	1024	2048		0%	100	100%
Very Large Boulder	2048	4096		0%	100	100%
		Total	100	100%		



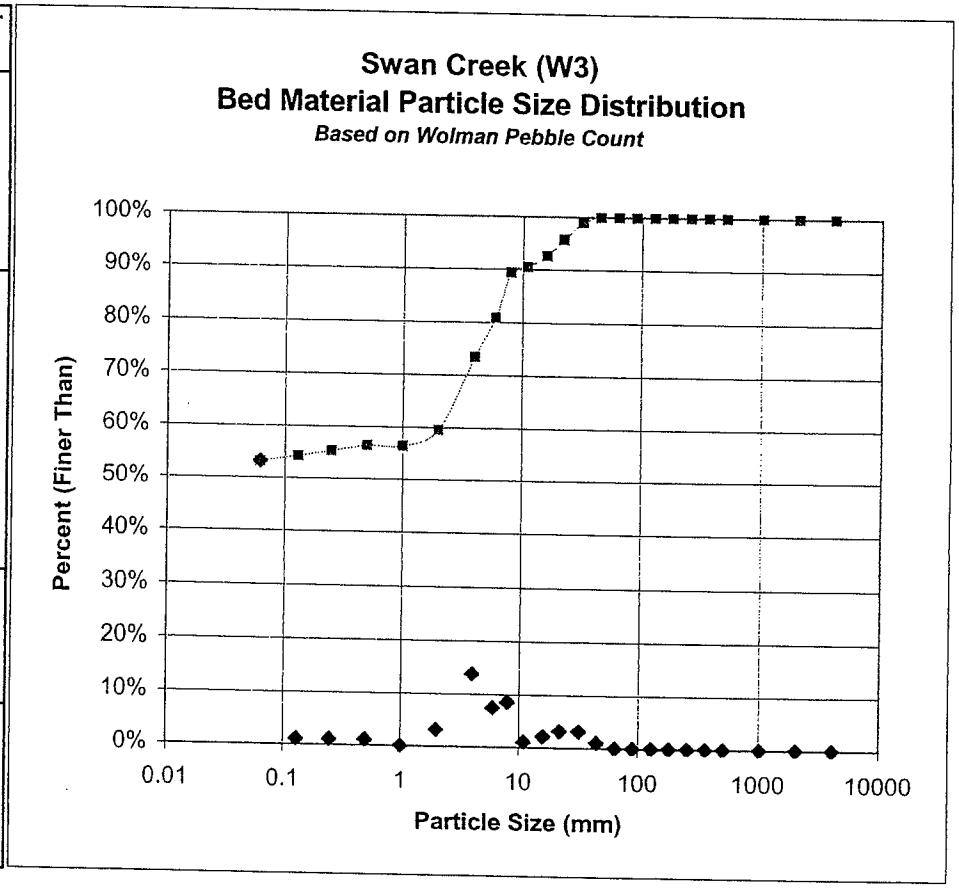
Project: Anchor Bay Watershed
No: G04211
Survey Date: 11/9/2004
Engineer: NGJ *Spreadsheet Computed by DF2*

Reference Reach: Swan Creek (W3) - Downstream of Palms Road

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Pebble Count Data

Material	Size Range (mm)		Count	% Count	Total Finer	% Finer Than
Silt / Clay	0	0.062	50	53%	50	53%
Very Fine Sand	0.062	0.13	1	1%	51	54%
Fine Sand	0.13	0.25	1	1%	52	55%
Medium Sand	0.25	0.5	1	1%	53	56%
Coarse Sand	0.5	1		0%	53	56%
Very Coarse Sand	1	2	3	3%	56	60%
Very Fine Gravel	2	4	13	14%	69	73%
Fine Gravel	4	6	7	7%	76	81%
Fine Gravel	6	8	8	9%	84	89%
Medium Gravel	8	11	1	1%	85	90%
Medium Gravel	11	16	2	2%	87	93%
Coarse Gravel	16	22	3	3%	90	96%
Coarse Gravel	22	32	3	3%	93	99%
Very Coarse Gravel	32	45	1	1%	94	100%
Very Coarse Gravel	45	64		0%	94	100%
Small Cobble	64	90		0%	94	100%
Medium Cobble	90	128		0%	94	100%
Large Cobble	128	180		0%	94	100%
Very Large Cobble	180	256		0%	94	100%
Small Boulder	256	362		0%	94	100%
Small Boulder	362	512		0%	94	100%
Medium Boulder	512	1024		0%	94	100%
Large Boulder	1024	2048		0%	94	100%
Very Large Boulder	2048	4096		0%	94	100%
		Total	94	100%		



Appendix 6: MDEQ Discharge Data

Project: Anchor Bay Watershed
No: G04211
Survey Date: 7/8/2005
Engineer: DF2

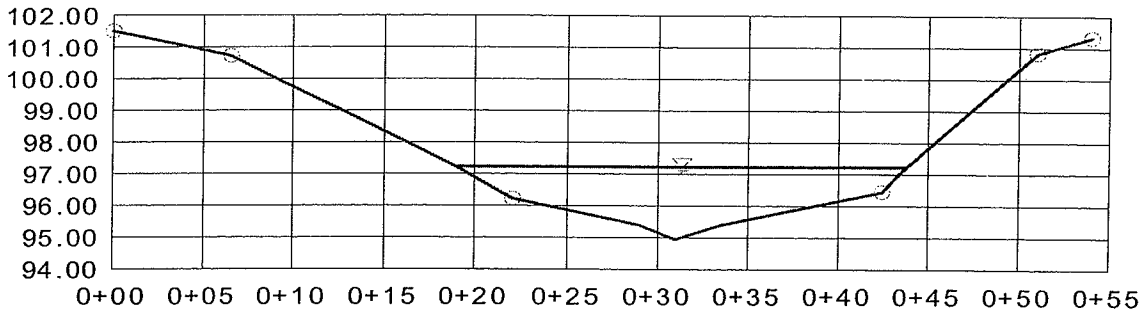
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Beaubien Creek (B2) - Downstream of Arnold Road

Rosgen - Level II Stream Type Classification

Input Information	
Stream Type	E
Dominate Bed Material	Silt-Clay
Floodprone Width	44 ft
Bankfull Width	24.76 ft
Bankfull Depth	2.27 ft
Entrenchment Ratio	1.78
Width / Depth Ratio	10.91
Sinuosity	NA
Channel Slope	0.0036 ft/ft
Level II Stream Type	**E 6**

Natural Channel Points	
Station (ft)	**Elevation (ft)**
0+00	101.51
0+07	100.76
0+19	97.21
0+22	96.25
0+29	95.39
0+31	94.94
0+34	95.42
0+43	96.44
0+44	97.08
0+51	100.83
0+54	101.34



Typical Cross Section

V:2.0
H:1
NTS

Project: Anchor Bay Watershed
No: G04211
Survey Date: 6/2/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

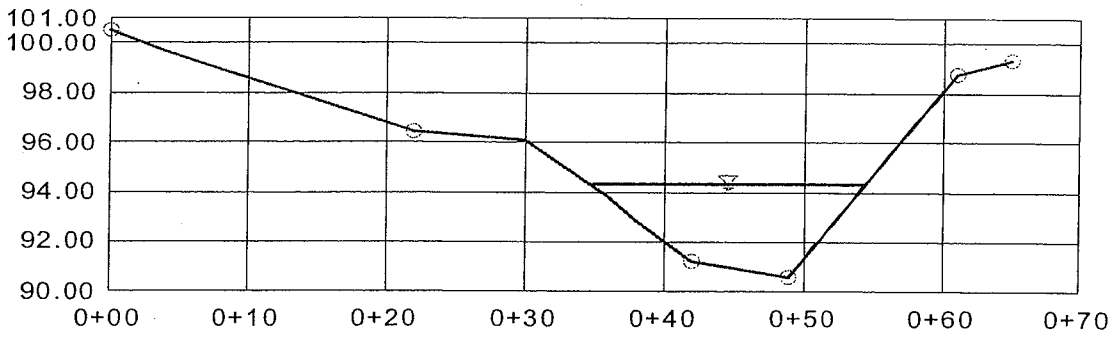
Reference Reach: Beaubien Creek (B5) - Downstream of Starville Road

Rosgen - Level II Stream Type Classification

Input Information	
Stream Type	E
Dominate Bed Material	Silt-Clay
Floodprone Width	57 ft
Bankfull Width	19.65 ft
Bankfull Depth	3.69 ft
Entrenchment Ratio	2.90
Width / Depth Ratio	5.33
Sinuosity	NA
Channel Slope	0.0028 ft/ft

Level II Stream Type E 6

Natural Channel Points	
Station (ft)	**Elevation (ft)**
0+00	100.54
0+04	99.69
0+22	96.46
0+30	96.1
0+36	93.85
0+38	92.92
0+42	91.22
0+49	90.61
0+61	98.74
0+65	99.32



Typical Cross Section

V:2.0
H:1
NTS

Project: Anchor Bay Watershed
No: G04211
Survey Date: 6/2/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

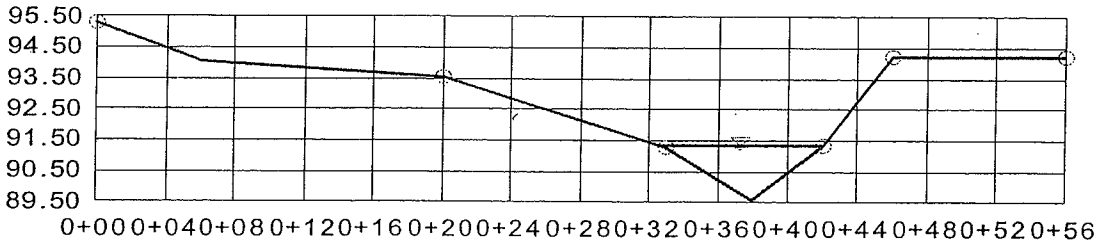
Reference Reach: Marsac Creek (M1) - Downstream of Springborn Road

Rosgen - Level II Stream Type Classification

Input Information	
Stream Type	E
Dominate Bed Material	Silt-Clay
Floodprone Width	40 ft
Bankfull Width	9.46 ft
Bankfull Depth	1.75 ft
Entrenchment Ratio	4.23
Width / Depth Ratio	5.41
Sinuosity	NA
Channel Slope	0.0009 ft/ft

Natural Channel Points	
Station (ft)	**Elevation (ft)**
0+00	95.3
0+06	94.01
0+20	93.53
0+33	91.26
0+38	89.59
0+42	91.34
0+46	94.22
0+56	94.23

Level II Stream Type **E 6**



V:2.0
H:1
NTS

Typical Cross Section

Project: Anchor Bay Watershed
No: G04211
Survey Date: 6/2/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

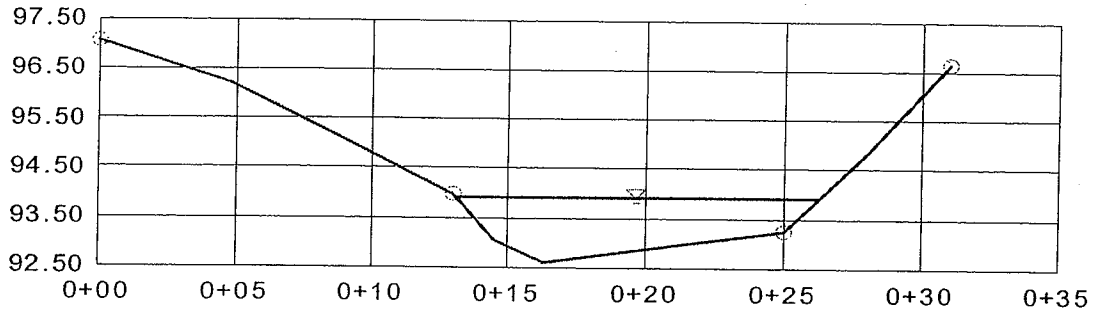
Reference Reach: Marsac Creek (M2) - Downstream of Marine City Highway

Rosgen - Level II Stream Type Classification

Input Information	
Stream Type	E
Dominate Bed Material	Silt-Clay
Floodprone Width	31 ft
Bankfull Width	13.13 ft
Bankfull Depth	1.32 ft
Entrenchment Ratio	2.36
Width / Depth Ratio	9.95
Sinuosity	NA
Channel Slope	0.0018 ft/ft

Natural Channel Points	
Station (ft)	**Elevation (ft)**
0+00	97.08
0+05	96.2
0+13	93.97
0+15	93.05
0+16	92.58
0+25	93.25
0+28	94.82
0+31	96.65

Level II Stream Type E6



Typical Cross Section

V:2.0
H:1
NTS

Project: Anchor Bay Watershed
No: G04211
Survey Date: 6/2/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

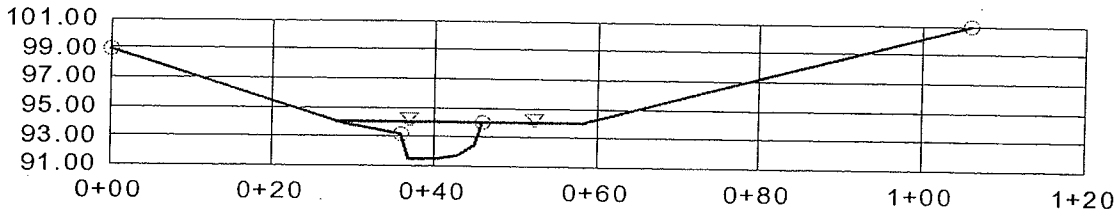
Reference Reach: Marsac Creek (M3) - Downstream of Bethuy Road

Rosgen - Level II Stream Type Classification

Input Information	
Stream Type	E
Dominate Bed Material	Silt-Clay
Floodprone Width	106 ft
Bankfull Width	30.45 ft
Bankfull Depth	2.59 ft
Entrenchment Ratio	3.48
Width / Depth Ratio	11.76
Sinuosity	NA
Channel Slope	0.0031 ft/ft

Level II Stream Type E6

Natural Channel Points	
Station (ft)	**Elevation (ft)**
0+00	98.91
0+29	93.83
0+36	93.2
0+37	91.46
0+40	91.41
0+43	91.68
0+45	92.42
0+46	94
0+58	93.93
1+06	100.94



V:2.0
H:1
NTS

Typical Cross Section

Project: Anchor Bay Watershed
No: G04211
Survey Date: 6/2/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

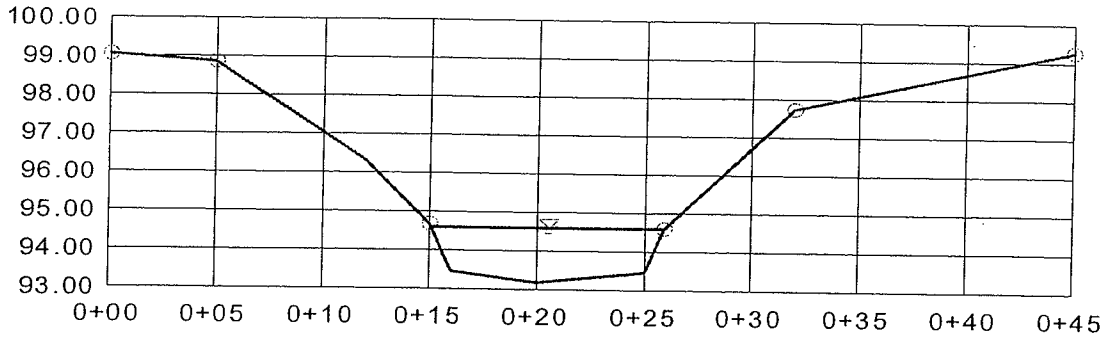
Reference Reach: Meldrum Drain (E0) - Downstream of Meisner Road

Rosgen - Level II Stream Type Classification

Input Information	
Stream Type	E
Dominate Bed Material	Silt-Clay
Floodprone Width	40 ft
Bankfull Width	10.91 ft
Bankfull Depth	1.42 ft
Entrenchment Ratio	3.67
Width / Depth Ratio	7.68
Sinuosity	NA
Channel Slope	0.0025 ft/ft

Natural Channel Points	
Station (ft)	**Elevation (ft)**
0+00	99.04
0+05	98.87
0+12	96.34
0+15	94.71
0+16	93.44
0+20	93.17
0+25	93.47
0+26	94.59
0+32	97.74
0+45	99.3

Level II Stream Type **E 6**



Typical Cross Section

V:2.0
H:1
NTS

Project: Anchor Bay Watershed
No: G04211
Survey Date: 6/2/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

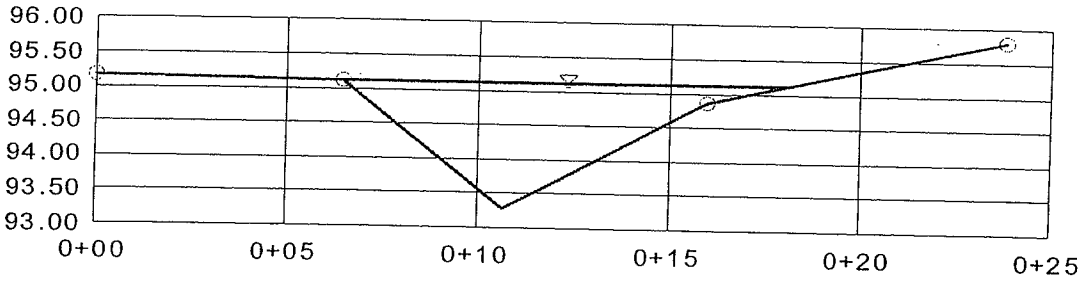
Reference Reach: Salt River (S1) - Downstream of 30 Mile Road

Rosgen - Level II Stream Type Classification

Input Information	
Stream Type	E
Dominate Bed Material	Silt-Clay
Floodprone Width	30 ft
Bankfull Width	11.63 ft
Bankfull Depth	1.84 ft
Entrenchment Ratio	2.58
Width / Depth Ratio	6.32
Sinuosity	NA
Channel Slope	0.0011 ft/ft

Natural Channel Points	
Station (ft)	**Elevation (ft)**
0+00	95.18
0+07	95.12
0+11	93.28
0+16	94.86
0+24	95.81

Level II Stream Type E 6



Typical Cross Section

V:2.0
H:1
NTS

Project: Anchor Bay Watershed
No: G04211
Survey Date: 6/2/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

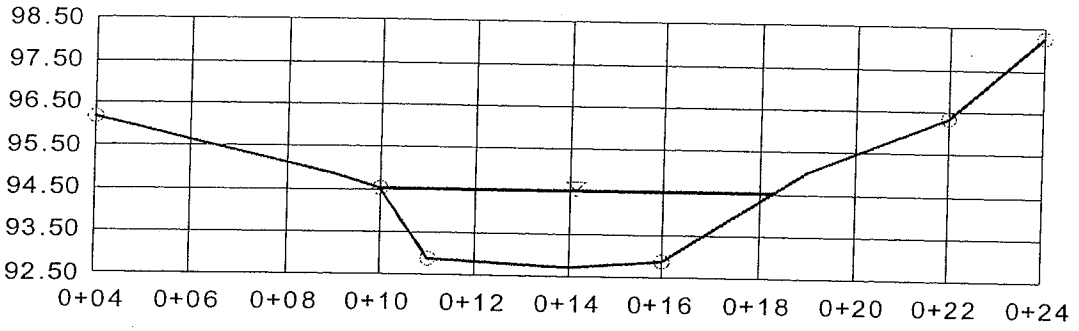
Reference Reach: Salt River (S2) - Downstream of 29 Mile Road

Rosgen - Level II Stream Type Classification

Input Information	
Stream Type	E
Dominate Bed Material	Silt-Clay
Floodprone Width	22 ft
Bankfull Width	8.29 ft
Bankfull Depth	1.81 ft
Entrenchment Ratio	2.65
Width / Depth Ratio	4.58
Sinuosity	NA
Channel Slope	0.0027 ft/ft

Natural Channel Points	
Station (ft)	**Elevation (ft)**
0+04	96.15
0+09	94.85
0+10	94.52
0+11	92.89
0+14	92.71
0+16	92.88
0+19	95.03
0+22	96.35
0+24	98.25

Level II Stream Type E 6



Typical Cross Section

V:1
H:1
NTS

Project: Anchor Bay Watershed
No: G04211
Survey Date: 6/2/2005
Engineer: DF2

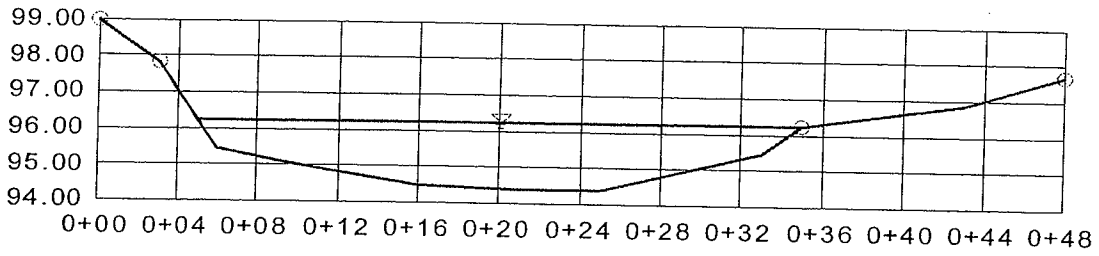
FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Salt River (S4) - Downstream of M-19

Rosgen - Level II Stream Type Classification

Input Information	
Stream Type	F
Dominate Bed Material	Silt-Clay
Floodprone Width	40 ft
Bankfull Width	29.97 ft
Bankfull Depth	1.84 ft
Entrenchment Ratio	1.33
Width / Depth Ratio	16.29
Sinuosity	NA
Channel Slope	0.00009 ft/ft
Level II Stream Type	F6

Natural Channel Points	
Station (ft)	**Elevation (ft)**
0+00	99
0+03	97.81
0+06	95.46
0+10	94.99
0+16	94.49
0+21	94.38
0+25	94.38
0+33	95.44
0+35	96.22
0+43	96.87
0+48	97.69



V:2.0
H:1
NTS

Typical Cross Section

Project: Anchor Bay Watershed
No: G04211
Survey Date: 7/8/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

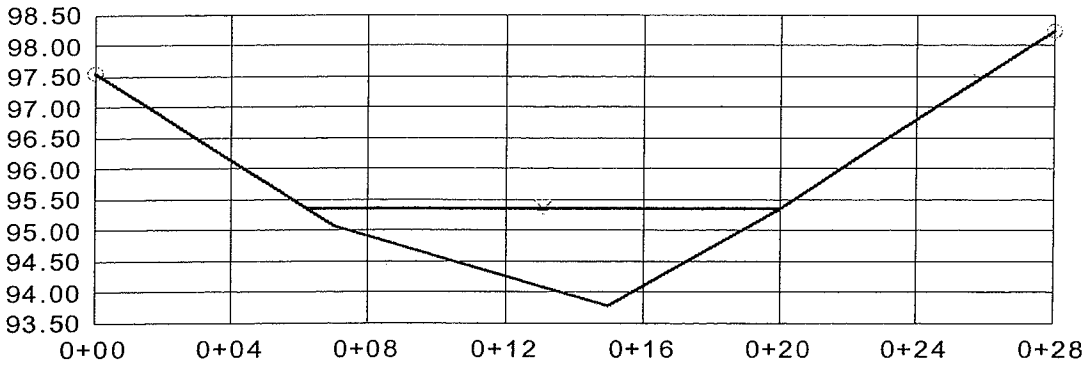
Reference Reach: Swan Creek (W0) - Downstream of Meldrum Road

Rosgen - Level II Stream Type Classification

Input Information	
Stream Type	E
Dominate Bed Material	Silt-Clay
Floodprone Width	25 ft
Bankfull Width	13.79 ft
Bankfull Depth	1.57 ft
Entrenchment Ratio	1.81
Width / Depth Ratio	8.78
Sinuosity	NA
Channel Slope	0.0027 ft/ft

Natural Channel Points	
Station (ft)	**Elevation (ft)**
0+00	97.54
0+07	95.07
0+15	93.78
0+20	95.35
0+28	98.22

Level II Stream Type **E 6**



Typical Cross Section

V:2.0
H:1
NTS

Project: Anchor Bay Watershed
No: G04211
Survey Date: 7/8/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

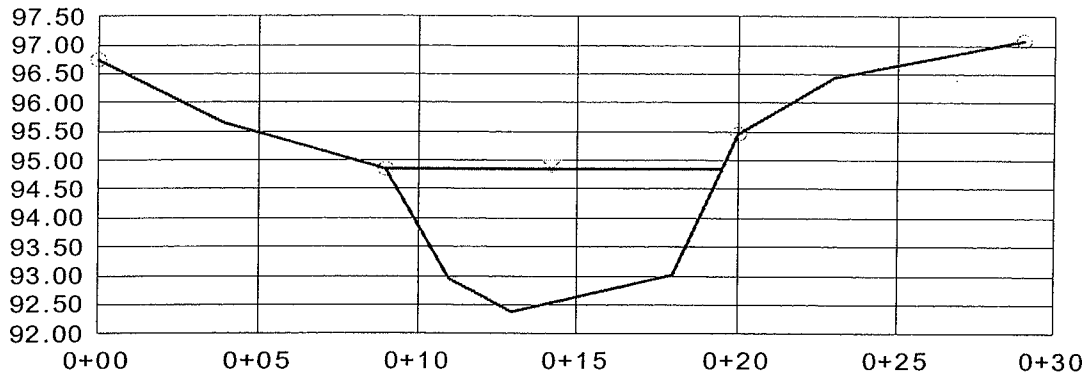
Reference Reach: Swan Creek (W2) - Downstream of Lindsey Road

Rosgen - Level II Stream Type Classification

Input Information	
Stream Type	E
Dominate Bed Material	Silt-Clay
Floodprone Width	23 ft
Bankfull Width	10.5 ft
Bankfull Depth	2.47 ft
Entrenchment Ratio	2.19
Width / Depth Ratio	4.25
Sinuosity	NA
Channel Slope	0.0001 ft/ft

Natural Channel Points	
Station (ft)	**Elevation (ft)**
0+00	96.73
0+04	95.64
0+09	94.86
0+11	92.96
0+13	92.39
0+18	93.03
0+20	95.47
0+23	96.43
0+29	97.07

Level II Stream Type **E 6**



Typical Cross Section

V:2.0
H:1
NTS

Project: Anchor Bay Watershed
No: G04211
Survey Date: 6/2/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

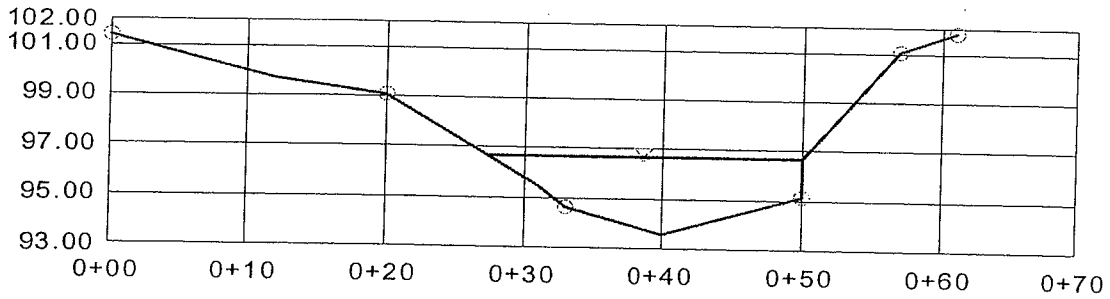
Reference Reach: Swan Creek (W3) - Downstream of Palms Road

Rosgen - Level II Stream Type Classification

Input Information	
Stream Type	E
Dominate Bed Material	Silt-Clay
Floodprone Width	57 ft
Bankfull Width	22.68 ft
Bankfull Depth	3.08 ft
Entrenchment Ratio	2.51
Width / Depth Ratio	7.36
Sinuosity	NA
Channel Slope	0.0003 ft/ft

Level II Stream Type E 6

Natural Channel Points	
Station (ft)	**Elevation (ft)**
0+00	101.38
0+12	99.69
0+20	99.09
0+31	95.47
0+33	94.64
0+40	93.6
0+50	95.11
0+50	96.68
0+57	101.02
0+61	101.8

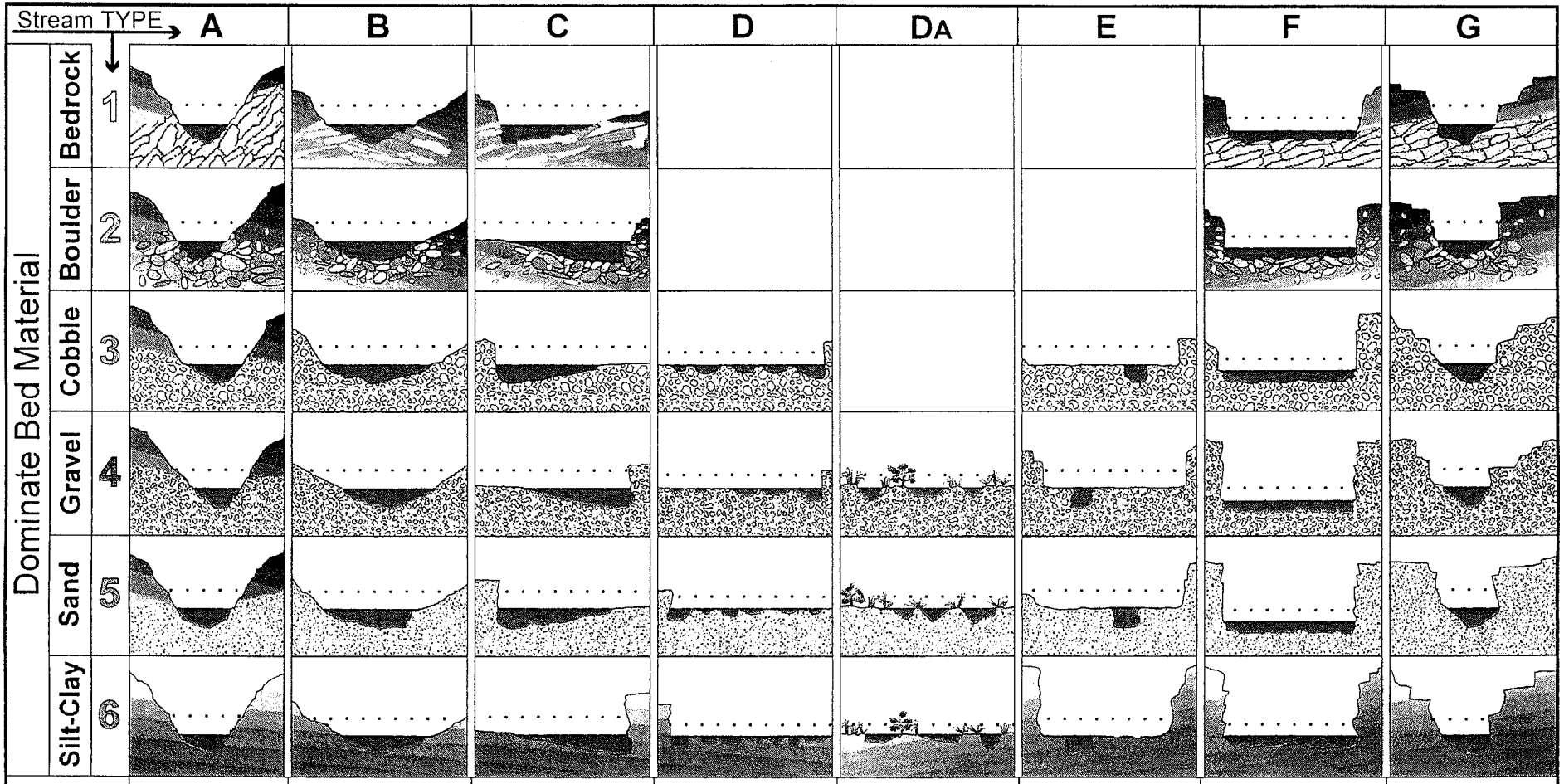


Typical Cross Section

V:2.0
H:1
NTS

Excerpts from *Applied River Morphology* by Dave Rosgen describe the E6 and F6 stream types as follows:

> The E6 stream types are channel systems with low to moderately sinuosity, gentle to moderately steep channel gradients, and very low channel width/depth ratios. The E6 stream types are found in a variety of land forms including high mountain meadows, alpine tundra, deltas, lacustrine valleys, and broad alluvial valleys with well developed floodplains. The E6 stream type is typically seen as a riffle/pool system with the dominant channel materials composed of silt-clay, interspersed with organic materials. Channel slopes are less than 2%, with a high number having slopes of less than 0.01%. Due to the inherently stable nature of the bed and banks, this stream type can exist on a wide range of slopes. Sinuosities and meander width ratios decrease, however, with and increase in slope. Streambanks are composed of materials similar to those of the dominant bed materials and are typically stabilized with riparian or wetland vegetation that forms densely rooted sod mats from grasses and grass like plants as well as woody species. Typically the E6 stream channel has high meander width ratios, high sinuosities, and low width/depth ratios. The E6 stream types are hydraulically efficient forms as they require the least cross-sectional area per unit of discharge. The narrow and relatively deep channels maintain a high resistance to plan form adjustment which results in channel stability without significant changes in sediment supply and/or streamflow occur.
>
> The F6 stream types are entrenched, meandering, gentle gradient streams deeply incised in cohesive sediments of silt and clay. The F6 stream channels have very high width/depth ratios, moderate sinuosities, and low to moderate meander width ratios. The "top of bank" elevation for this stream type is much greater than the bankfull stage which is indicative of the deep entrenchment. The related landforms are often seen as terrace bounded alluvial valleys, deltas, and costal planes. Depositional soils in these valleys often originate from fine alluvial, eolian (loess), and lacustrine deposits. The F6 stream banks are relatively more stable than the F3, F4, or F5 stream banks, due to their inherent cohesive nature and ability to "stand" much steeper. Deep rooted riparian vegetation is much more effective at maintaining stability in the cohesive bank materials. However, mass wasting due to bank saturation/liquefaction and collapse is still a prevalent process in hydro-physiographic provinces where the composition of riparian vegetation is poor and natural densities have been reduced. The F6 stream systems produce relatively low bedload sediment yields due to the lack of coarse material in the channels, thus, excessive bar deposition is not generally observed with the F6 stream type. These stream types are very sensitive to disturbance and adjust rapidly to changes in flow regime and sediment supply from the watershed.

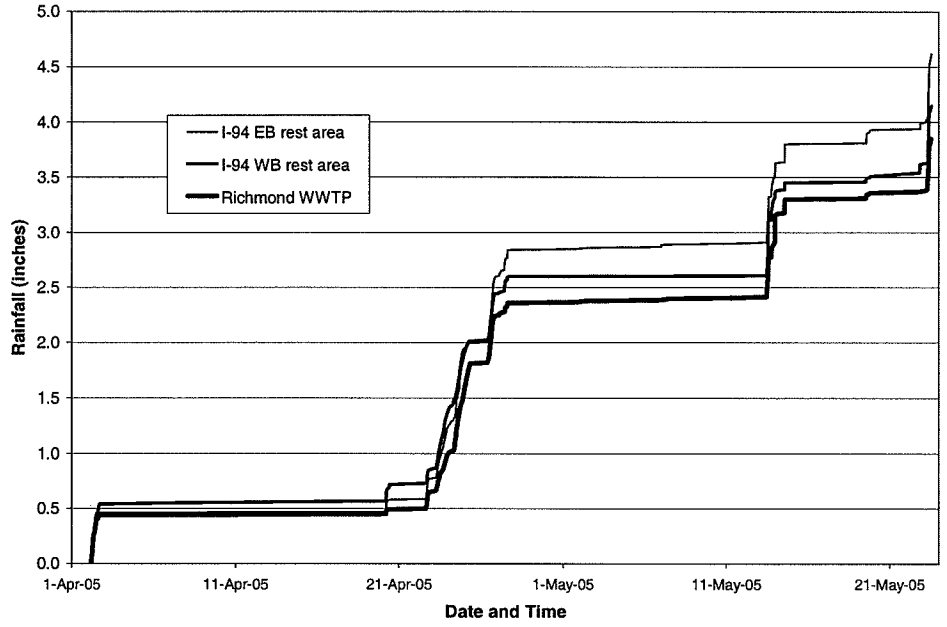


	A	B	C	D	DA	E	F	G
Entrchmnt.	< 1.4	1.4 - 2.2	> 2.2	n/a	> 4.0	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 40	< 12	> 12	< 12
Sinuosity	1 - 1.2	> 1.2	> 1.2	n/a	variable	>1.5	> 1.2	>1.2
Slope	.04-.099	.02-.039	< .02	< .04	< .005	< .02	< .02	.02-.039

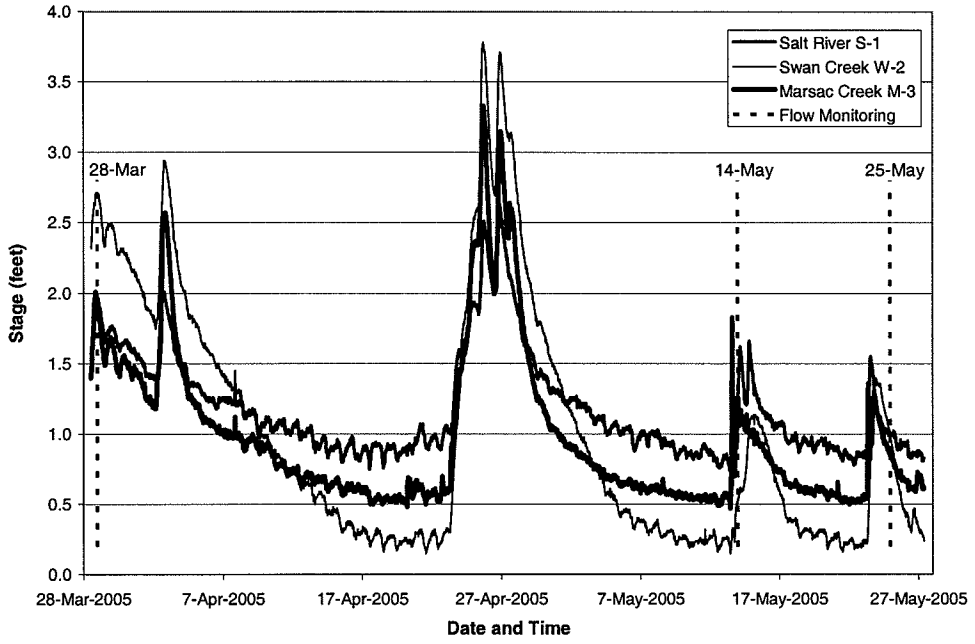
FIGURE 5-2. Primary delineative criteria for the major stream types.

Appendix 7: Rainfall Data

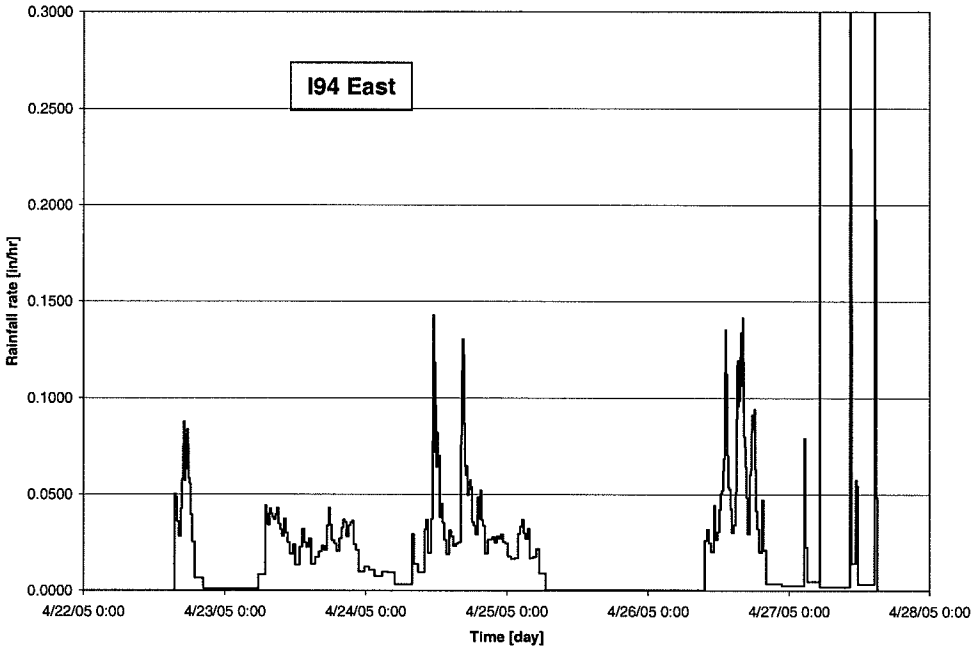
Appendix 7: Rainfall Data



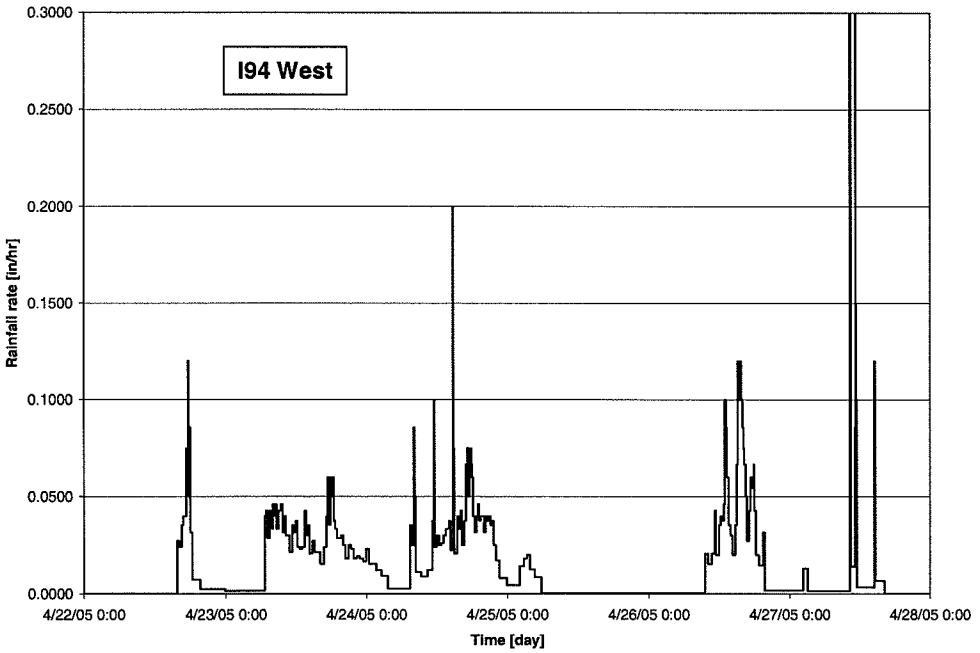
Cumulative Rainfall Depth over Entire Period of Monitoring



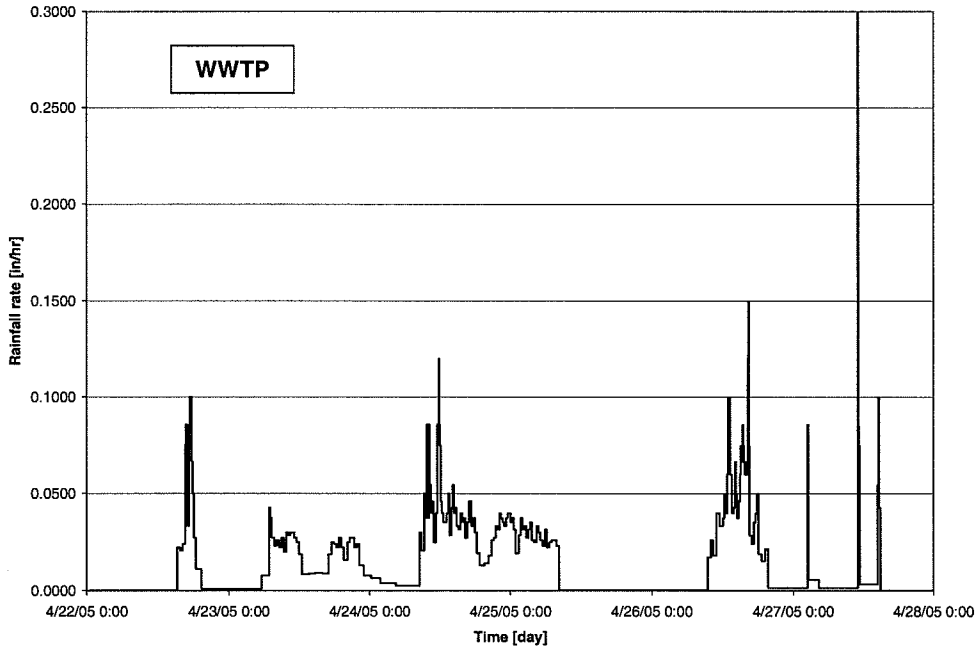
Stream Stage Record over Entire Period of Monitoring



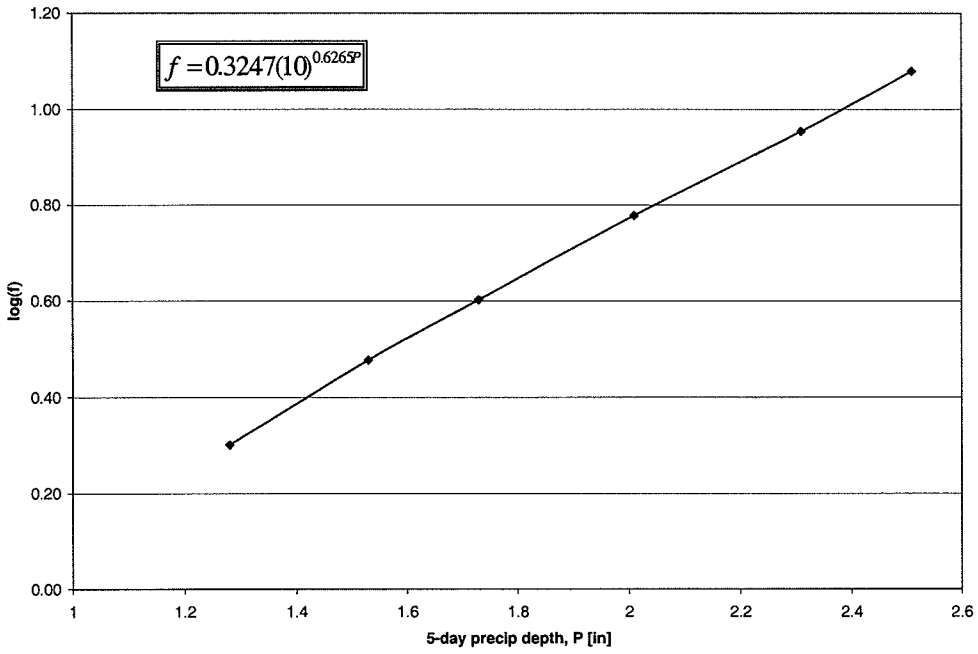
Rainfall Hyetograph for Five-Day Rainfall Event - Eastbound Interstate 94 Rest Area



Rainfall Hyetograph for Five-Day Rainfall Event - Westbound Interstate 94 Rest Area



Rainfall Hyetograph for Five-Day Rainfall Event - Richmond Wastewater Treatment Plant



Frequency Analysis for a Five-Day Rainfall Event
Data from State of Illinois Water Survey Bulletin 71

Appendix 8: Stream Flow Monitoring

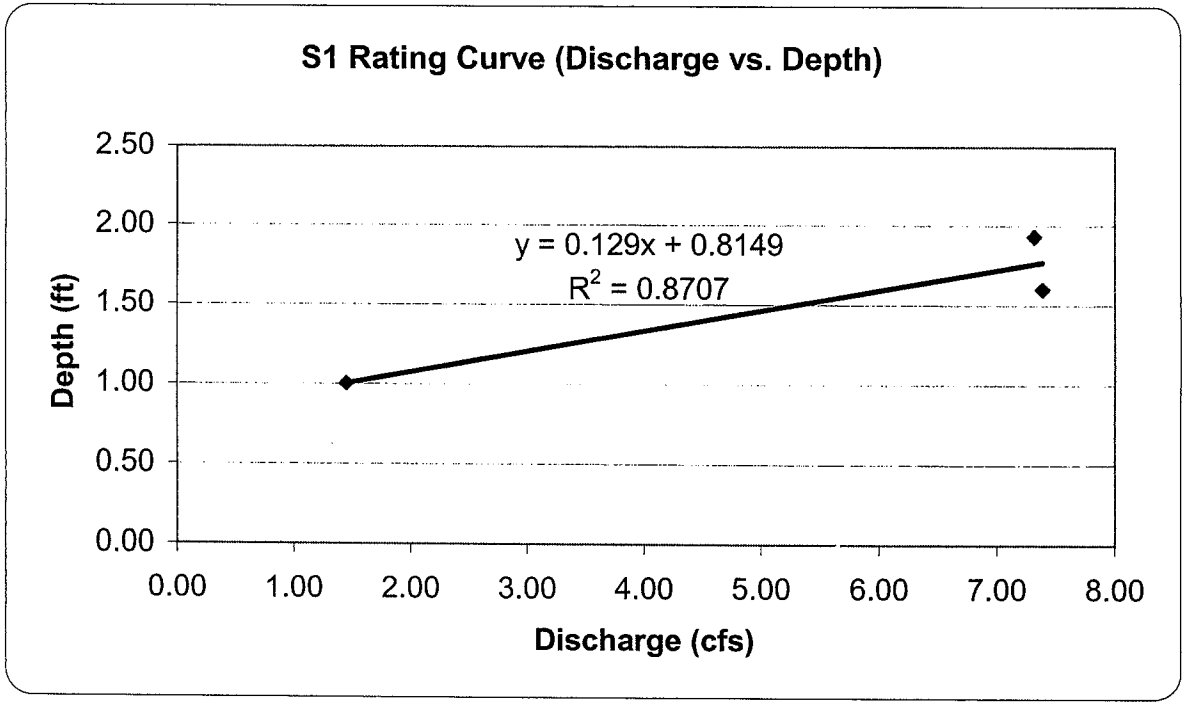
Project: Anchor Bay Watershed
No: G04211
Survey Date: 7/8/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Salt River (S1) - Downstream of 30 Mile Road

S1 Rating Curve (Discharge vs. Depth)

Discharge (cfs)	Depth (ft)	Area (ft^2)
1.45	1.00	6.09
7.39	1.60	11.00
7.32	1.93	14.18



Theoretical Bankfull Event

Bankfull Depth (ft)	1.84
Bankfull Flow Area (ft^2)	9.7
Bankfull Discharge (cfs)	8.56
Frequency (Years)	0.6

Measurement Date: 3/28/2005
Location: S1 - Salt River
Measurement by: KEE
Stage:
Method: 6/10
No. of Sections: 20

Rating Constants

Rev's <=40	2.2048	0.0178
Rev's >40	2.2048	0.0178

Width: 11.4 ft **Q:** 7.32 cfs **Area:** 14.18 ft² **Avg Velocity:** 0.52 ft/s

USGS STD Pygmy rating V=2.2048R+.013

	Distance	Width (ft)	Observation Depth	Depth (ft)	Revolutions	Time (sec)	Velocity (fps)	Avg Velocity (fps)	Area (sft)	Discharge (cfs)
1	3.1	0.30	0.0	0.00	0	0.0	0.00	0.00	0.00	0.00
1	3.7	0.60	0.6	0.33	1	51.6	0.06	0.06	0.20	0.01
1	4.3	0.60	0.6	0.51	2	45.4	0.11	0.11	0.31	0.03
1	4.9	0.60	0.6	0.72	2	47.5	0.11	0.11	0.43	0.05
1	5.5	0.60	0.6	1.21	3	57.1	0.13	0.13	0.73	0.09
1	6.1	0.60	0.6	1.74	3	45.6	0.16	0.16	1.04	0.17
1	6.7	0.60	0.6	1.92	5	42.0	0.28	0.28	1.15	0.32
1	7.3	0.60	0.6	1.93	7	41.4	0.39	0.39	1.16	0.45
1	7.9	0.60	0.6	1.89	9	41.9	0.49	0.49	1.13	0.55
1	8.5	0.60	0.6	1.81	13	41.3	0.71	0.71	1.09	0.77
1	9.1	0.60	0.6	1.80	16	40.6	0.89	0.89	1.08	0.96
1	9.7	0.60	0.6	1.71	17	40.3	0.95	0.95	1.03	0.98
1	10.3	0.60	0.6	1.62	16	42.0	0.86	0.86	0.97	0.83
1	10.9	0.60	0.6	1.50	15	41.7	0.81	0.81	0.90	0.73
1	11.5	0.60	0.6	1.49	13	40.0	0.73	0.73	0.89	0.65
1	12.1	0.60	0.6	1.23	8	41.1	0.45	0.45	0.74	0.33
1	12.7	0.60	0.6	1.02	8	42.1	0.44	0.44	0.61	0.27
1	13.3	0.60	0.6	0.79	5	43.1	0.27	0.27	0.47	0.13
1	13.9	0.60	0.6	0.42	0	0.0	0.00	0.00	0.25	0.00
1	14.5	0.30	0.0	0.00	0	0.0	0.00	0.00	0.00	0.00
	Total	11.4						0.52	14.18	7.32

Measurement Date: 5/14/2005
Location: S1 - Salt River
Measurement by: KEE
Stage:
Method: 6/10
No. of Sections: 27

Rating Constants
Rev's <=40 2.2048 0.0178
Rev's >40 2.2048 0.0178

Width: 10.7 ft **Q:** 7.39 cfs **Area:** 11.00 ft² **Avg Velocity:** 0.67 ft/s
USGS STD Pygmy rating V=2.2048R+.013

	Distance	Width (ft)	Observation Depth	Depth (ft)	Revolutions	Time (sec)	Velocity (fps)	Avg Velocity (fps)	Area (sft)	Discharge (cfs)
1	3.9	0.25	0.0	0.00	0	0	0.00	0.00	0.00	0.00
1	4.4	0.50	0.6	0.10	0	60	0.02	0.02	0.05	0.00
1	4.9	0.50	0.6	0.40	0	60	0.02	0.02	0.20	0.00
1	5.4	0.50	0.6	0.70	0	60	0.02	0.02	0.35	0.01
1	5.9	0.50	0.6	0.90	3	60	0.13	0.13	0.45	0.06
1	6.4	0.50	0.6	1.45	6	60	0.24	0.24	0.73	0.18
1	6.9	0.50	0.6	1.50	9	60	0.35	0.35	0.75	0.26
1	7.4	0.50	0.6	1.60	10	60	0.39	0.39	0.80	0.31
1	7.9	0.50	0.6	1.60	23	60	0.86	0.86	0.80	0.69
1	8.4	0.50	0.6	1.60	23	60	0.86	0.86	0.80	0.69
1	8.9	0.50	0.6	1.55	31	60	1.16	1.16	0.78	0.90
1	9.4	0.50	0.6	1.50	32	60	1.19	1.19	0.75	0.89
1	9.9	0.50	0.6	1.40	30	60	1.12	1.12	0.70	0.78
1	10.4	0.50	0.6	1.40	33	60	1.23	1.23	0.70	0.86
1	10.9	0.50	0.6	1.28	31	60	1.16	1.16	0.64	0.74
1	11.4	0.50	0.6	1.20	25	60	0.94	0.94	0.60	0.56
1	11.9	0.50	0.6	1.10	9	60	0.35	0.35	0.55	0.19
1	12.4	0.50	0.6	0.95	4	60	0.16	0.16	0.48	0.08
1	12.9	0.50	0.6	0.80	12	60	0.46	0.46	0.40	0.18
1	13.4	0.50	0.6	0.50	0	60	0.02	0.02	0.25	0.01
1	13.9	0.50	0.6	0.35	0	60	0.00	0.00	0.18	0.00
1	14.4	0.35	0.6	0.10	0	60	0.02	0.02	0.04	0.00
1	14.6	0.10	0.0	0.00	0	0	0.00	0.00	0.00	0.00
	Total	10.70						0.67	11.00	7.39

Measurement Date: 5/25/2005
Location: S1 - Salt River
Measurement by: KEE
Stage:
Method: 6/10
No. of Sections: 21

Rating Constants

Rev's <=40	**2.2048**	**0.0178**
Rev's >40	**2.2048**	**0.0178**

Width: 8.0 ft **Q: 1.45 cfs** **Area: 6.09 ft²** **Avg Velocity: 0.24 ft/s**

USGS STD Pygmy rating V=2.2048R+.013

	Distance	Width (ft)	Observation Depth	Depth (ft)	Revolutions	Time (sec)	Velocity (fps)	Avg Velocity (fps)	Area (sft)	Discharge (cfs)
1	3.0	0.25	0.0	0.00	0	0	0.00	0.00	0.00	0.00
1	3.5	0.50	0.6	0.40	0	60	0.02	0.02	0.20	0.00
1	4.0	0.50	0.6	0.90	0	60	0.02	0.02	0.45	0.01
1	4.5	0.50	0.6	0.95	0	60	0.02	0.02	0.48	0.01
1	5.0	0.50	0.6	1.00	0	60	0.02	0.02	0.50	0.01
1	5.5	0.50	0.6	1.00	0	60	0.02	0.02	0.50	0.01
1	6.0	0.50	0.6	1.00	7	60	0.28	0.28	0.50	0.14
1	6.5	0.50	0.6	1.00	9	60	0.35	0.35	0.50	0.18
1	7.0	0.50	0.6	0.90	19	60	0.72	0.72	0.45	0.32
1	7.5	0.50	0.6	0.90	17	60	0.64	0.64	0.45	0.29
1	8.0	0.50	0.6	0.85	18	60	0.68	0.68	0.43	0.29
1	8.5	0.50	0.6	0.80	8	60	0.31	0.31	0.40	0.12
1	9.0	0.50	0.6	0.75	3	60	0.13	0.13	0.38	0.05
1	9.5	0.50	0.6	0.70	0	60	0.02	0.02	0.35	0.01
1	10.0	0.50	0.6	0.60	0	60	0.02	0.02	0.30	0.01
1	10.5	0.50	0.6	0.40	0	60	0.02	0.02	0.20	0.00
1	11.0	0.25	0.6	0.00	0	60	0.02	0.02	0.00	0.00
	Total	8.00						0.24	6.09	1.45

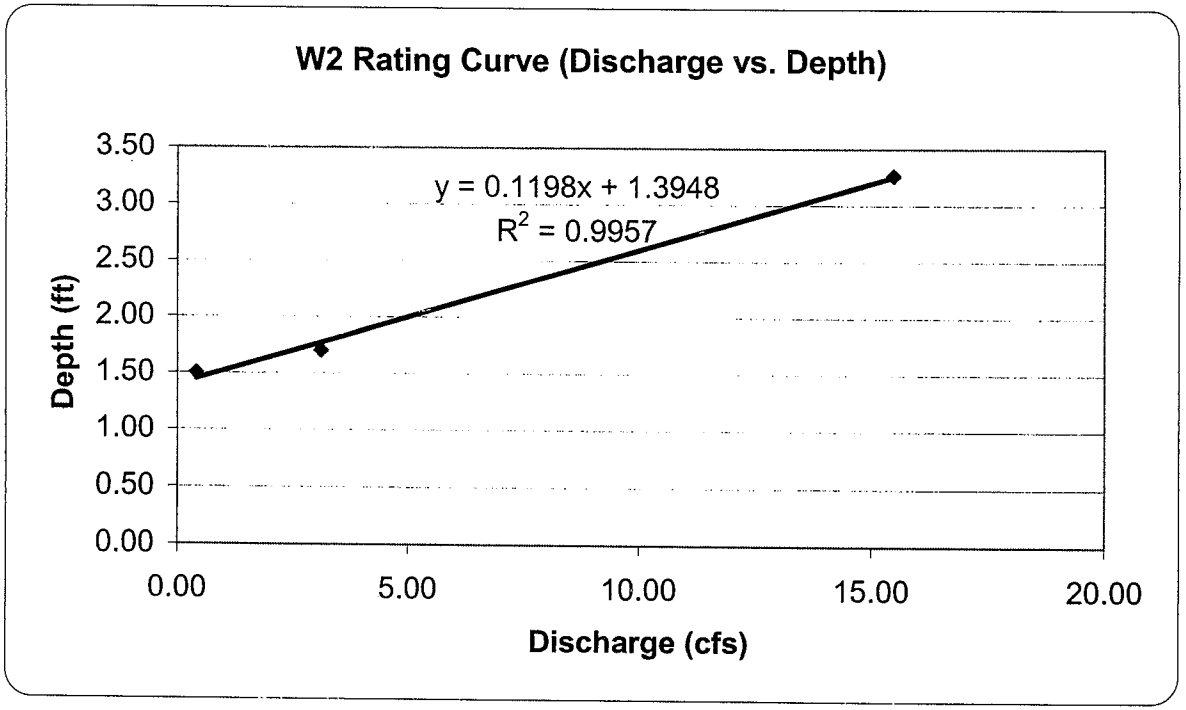
Project: Anchor Bay Watershed
No: G04211
Survey Date: 7/8/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Swan Creek (W2) - Downstream of Lindsey Road

W2 Rating Curve (Discharge vs. Depth)

Discharge (cfs)	Depth (ft)	Area (ft^2)
0.41	1.50	10.00
3.12	1.70	11.22
15.47	3.26	28.53



Theoretical Bankfull Event

Bankfull Depth (ft)	2.47
Bankfull Flow Area (ft^2)	18.4
Bankfull Discharge (CFS)	11.95
Frequency (Years)	0.6

Measurement Date: 3/28/2005
Location: W2 - Swan Creek
Measurement by: KEE
Stage:
Method: 6/10 and 2/10, 8/10
No. of Sections: 23

Rating Constants
Rev's <=40 2.2048 0.0178
Rev's >40 2.2048 0.0178

Width: 12.9 ft **Q: 15.50 cfs** **Area: 28.53 ft²** **Avg Velocity: 0.54 ft/s**
USGS STD Pygmy rating V=2.2048R+.013

	Distance	Width (ft)	Observation Depth	Depth (ft)	Revolutions	Time (sec)	Velocity (fps)	Avg Velocity (fps)	Area (sft)	Discharge (cfs)
1	3.7	0.30	0.0	0.00	0	0.0	0.00	0.00	0.00	0.00
1	4.3	0.60	0.6	0.44	0	0.0	0.00	0.00	0.26	0.00
1	4.9	0.60	0.6	0.58	0	0.0	0.00	0.00	0.35	0.00
1	5.5	0.60	0.6	0.82	2	53.8	0.10	0.10	0.49	0.05
1	6.1	0.60	0.6	1.51	4	50.5	0.19	0.19	0.91	0.17
1	6.7	0.60	0.6	2.02	6	44.3	0.32	0.32	1.21	0.39
1	7.3	0.60	0.6	2.41	8	41.2	0.45	0.45	1.45	0.65
1	7.9	0.60	0.2	2.89	9	42.6	0.37	0.43	1.73	0.74
			0.8		7	44.1	0.48			
1	8.5	0.60	0.2	2.98	10	40.9	0.56	0.57	1.79	1.02
			0.8		11	43.2	0.58			
1	9.1	0.60	0.2	3.03	11	42.1	0.65	0.62	1.82	1.13
			0.8		12	42.1	0.59			
1	9.7	0.60	0.2	3.12	12	40.5	0.67	0.66	1.87	1.23
			0.8		12	42.4	0.64			
1	10.3	0.60	0.2	3.20	12	41.2	0.73	0.70	1.92	1.33
			0.8		13	40.2	0.66			
1	10.9	0.60	0.2	3.23	14	40.7	0.78	0.78	1.94	1.50
			0.8		14	40.9	0.77			
1	11.5	0.60	0.2	3.26	14	42.0	0.75	0.75	1.96	1.47
			0.8		14	42.2	0.75			
1	12.1	0.60	0.2	3.22	13	41.0	0.72	0.75	1.93	1.45
			0.8		14	40.6	0.78			
1	12.7	0.60	0.2	3.13	15	42.9	0.61	0.70	1.88	1.31
			0.8		11	41.2	0.79			
1	13.3	0.60	0.2	3.08	11	41.9	0.6	0.65	1.85	1.20
			0.8		13	43.3	0.7			
1	13.9	0.60	0.2	2.79	13	42.0	0.36	0.53	1.67	0.89
			0.8		7	45.0	0.7			
1	14.5	0.60	0.6	2.24	11	43.9	0.57	0.57	1.34	0.77
1	15.1	0.60	0.6	1.88	3	45.4	0.16	0.16	1.13	0.18
1	15.7	0.60	0.6	1.28	0	0.0	0.00	0.00	0.77	0.00
1	16.3	0.45	0.6	0.58	0	0.0	0.00	0.00	0.26	0.00
1	16.6	0.15	0.0	0.00	0	0.0	0.00	0.00	0.00	0.00
	Total	12.90						0.54	28.53	15.47

Measurement Date: 5/14/2005
Location: W2 - Swan Creek
Measurement by: KEE
Stage:
Method: 6/10
No. of Sections: 19

Rating Constants
Rev's <=40 **2.2048** 0.0178
Rev's >40 **2.2048** 0.0178

Width: 9.5 ft **Q: 0.41 cfs** **Area: 10.00 ft²** **Avg Velocity: 0.04 ft/s**
USGS STD Pygmy rating V=2.2048R+.013

	Distance	Width (ft)	Observation Depth	Depth (ft)	Revolutions	Time (sec)	Velocity (fps)	Avg Velocity (fps)	Area (sft)	Discharge (cfs)
1	3.0	0.25	0.0	0.00	0	0	0.00	0.00	0.00	0.00
1	3.5	0.50	0.6	0.30	0	60	0.00	0.00	0.15	0.00
1	4.0	0.50	0.6	0.70	0	60	0.00	0.00	0.35	0.00
1	4.5	0.50	0.6	1.20	0	60	0.02	0.02	0.60	0.01
1	5.0	0.50	0.6	1.20	1	60	0.05	0.05	0.60	0.03
1	5.5	0.50	0.6	1.35	0	60	0.02	0.02	0.68	0.01
1	6.0	0.50	0.6	1.40	1	60	0.05	0.05	0.70	0.04
1	6.5	0.50	0.6	1.40	1	60	0.05	0.05	0.70	0.04
1	7.0	0.50	0.6	1.45	1	60	0.05	0.05	0.73	0.04
1	7.5	0.50	0.6	1.50	0	60	0.02	0.02	0.75	0.02
1	8.0	0.50	0.6	1.50	2	60	0.09	0.09	0.75	0.07
1	8.5	0.50	0.6	1.50	2	60	0.09	0.09	0.75	0.07
1	9.0	0.50	0.6	1.45	1	60	0.05	0.05	0.73	0.04
1	9.5	0.50	0.6	1.35	0	60	0.02	0.02	0.68	0.01
1	10.0	0.50	0.6	1.30	0	60	0.02	0.02	0.65	0.01
1	10.5	0.50	0.6	1.20	0	60	0.02	0.02	0.60	0.01
1	11.0	0.50	0.6	0.70	0	60	0.02	0.02	0.35	0.01
1	11.5	0.50	0.6	0.45	0	60	0.02	0.02	0.23	0.00
1	12.0	0.50	0.0	0.00	0	60	0.02	0.00	0.00	0.00
1	12.5	0.25	0.0	0.00	0	60	0.02	0.02	0.00	0.00
	Total	9.50						0.04	10.00	0.41

Measurement Date: 5/25/2005
Location: W2 - Swan Creek
Measurement by: KEE
Stage:
Method: 6/10
No. of Sections: 18

Rating Constants
Rev's <=40 **2.2048** 0.0178
Rev's >40 **2.2048** 0.0178

Width: 8.7 ft **Q: 3.12 cfs** **Area: 11.22 ft²** **Avg Velocity: 0.28 ft/s**
USGS STD Pygmy rating V=2.2048R+.013

	Distance	Width (ft)	Observation Depth	Depth (ft)	Revolutions	Time (sec)	Velocity (fps)	Avg Velocity (fps)	Area (sft)	Discharge (cfs)
1	1.8	0.25	0.0	0.00	0	0	0.00	0.00	0.00	0.00
1	2.3	0.50	0.6	0.90	0	60	0.00	0.00	0.45	0.00
1	2.8	0.50	0.6	1.40	0	60	0.00	0.00	0.70	0.00
1	3.3	0.50	0.6	1.40	0	60	0.02	0.02	0.70	0.01
1	3.8	0.50	0.6	1.40	1	60	0.05	0.05	0.70	0.04
1	4.3	0.50	0.6	1.50	10	60	0.39	0.39	0.75	0.29
1	4.8	0.50	0.6	1.50	12	60	0.46	0.46	0.75	0.35
1	5.3	0.50	0.6	1.60	14	60	0.53	0.53	0.80	0.42
1	5.8	0.50	0.6	1.70	13	60	0.50	0.50	0.85	0.43
1	6.3	0.50	0.6	1.65	13	60	0.50	0.50	0.83	0.42
1	6.8	0.50	0.6	1.70	10	60	0.39	0.39	0.85	0.33
1	7.3	0.50	0.6	1.60	10	60	0.39	0.39	0.80	0.31
1	7.8	0.50	0.6	1.50	11	60	0.42	0.42	0.75	0.32
1	8.3	0.50	0.6	1.40	5	60	0.20	0.20	0.70	0.14
1	8.8	0.50	0.6	1.40	1	60	0.05	0.05	0.70	0.04
1	9.3	0.50	0.6	1.10	0	60	0.02	0.02	0.55	0.01
1	9.8	0.50	0.6	0.60	0	60	0.02	0.02	0.30	0.01
1	10.3	0.35	0.6	0.10	0	60	0.02	0.02	0.04	0.00
1	10.5	0.10	0.0	0.00	0	60	0.02	0.00	0.00	0.00
	Total	8.70						0.28	11.22	3.12

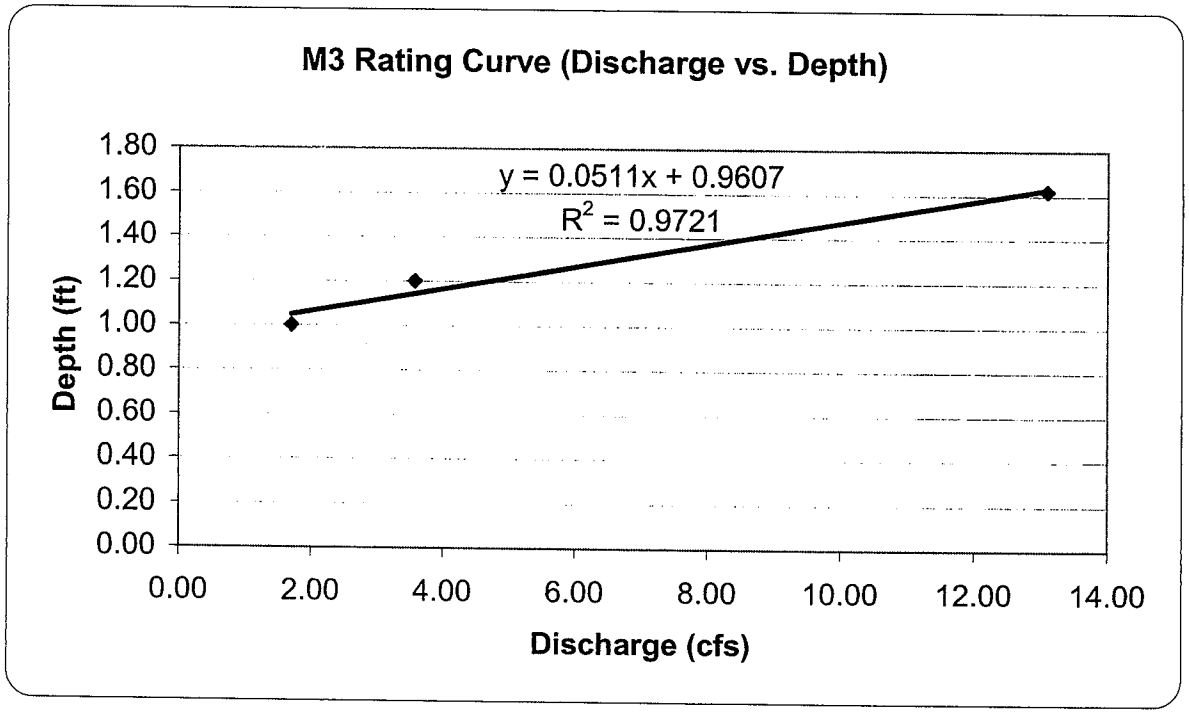
Project: Anchor Bay Watershed
No: G04211
Survey Date: 7/8/2005
Engineer: DF2

FISHBECK, THOMPSON, CARR & HUBER, INC.
1515 Arboretum Drive, SE
Grand Rapids, MI 49546
616-575-3824

Reference Reach: Marsac Creek (M3) - Downstream of Bethuy Road

M3 Rating Curve (Discharge vs. Depth)

Discharge (cfs)	Depth (ft)	Area (ft^2)
1.70	1.00	4.48
3.57	1.20	6.73
13.09	1.62	10.01



Theoretical Bankfull Event

Bankfull Depth (ft)	2.59
Bankfull Flow Area (ft^2)	25.3
Bankfull Discharge (CFS)	56.11
Frequency (Years)	0.8

Measurement Date: 3/28/2005
Location: M3 - Marsac Creek
Measurement by: KEE
Stage:
Method: 6/10 and 2/10, 8/10
No. of Sections: 20

Rating Constants
Rev's <=40 2.2048 0.0178
Rev's >40 2.2048 0.0178

Width: 7.7 ft **Q:** 13.10 cfs **Area:** 10.01 ft² **Avg Velocity:** 1.31 ft/s
USGS STD Pygmy rating V=2.2048R+.013

	Distance	Width (ft)	Observation Depth	Depth (ft)	Revolutions	Time (sec)	Velocity (fps)	Avg Velocity (fps)	Area (sft)	Discharge (cfs)
1	2.4	0.20	0.0	0.00	0	0.0	0.00	0.00	0.00	0.00
1	2.8	0.40	0.6	0.90	10	44.2	0.52	0.52	0.36	0.19
1	3.2	0.40	0.6	1.20	19	40.4	1.05	1.05	0.48	0.50
1	3.6	0.40	0.6	1.29	26	40.4	1.44	1.44	0.52	0.75
1	4.0	0.40	0.6	1.38	29	40.4	1.60	1.60	0.55	0.88
1	4.4	0.40	0.6	1.48	36	40.9	1.96	1.96	0.59	1.16
1	4.8	0.40	0.2	1.55	32	40.8	0.78	0.00	0.62	0.53
			0.8		38	40.5	0.93	0.86	0.00	0.00
1	5.2	0.40	0.2	1.62	28	40.9	0.69	0.00	0.65	0.54
			0.8		40	40.7	0.97	0.83	0.00	0.00
1	5.6	0.40	0.2	1.62	35	41.0	0.85	0.00	0.65	0.60
			0.8		41	40.9	0.99	0.92	0.00	0.00
1	6	0.40	0.2	1.62	36	41.3	0.87	0.00	0.65	0.61
			0.8		41	40.5	1.00	0.94	0.00	0.00
1	6.4	0.40	0.2	1.62	36	41.0	0.87	0.00	0.65	0.65
			0.8		46	40.3	1.13	1.00	0.00	0.00
1	6.8	0.40	0.2	1.60	39	40.1	0.97	0.00	0.64	0.67
			0.8		46	40.5	1.12	1.05	0.00	0.00
1	7.2	0.40	0.2	1.54	42	40.7	1.02	0.00	0.62	0.64
			0.8		43	40.9	1.04	1.03	0.00	0.00
1	7.6	0.40	0.6	1.46	44	40.6	2.41	2.41	0.58	1.40
1	8.0	0.40	0.6	1.38	44	40.7	2.40	2.40	0.55	1.32
1	8.4	0.40	0.6	1.22	40	40.3	2.21	2.21	0.49	1.08
1	8.8	0.40	0.6	1.07	33	41.5	1.77	1.77	0.43	0.76
1	9.2	0.40	0.6	1.32	29	42.6	1.52	1.52	0.53	0.81
1	9.6	0.45	0.6	1.01	0	0.0	0.00	0.00	0.45	0.00
1	10.1	0.25	0.0	0.00	0	0.0	0.00	0.00	0.00	0.00
	Total	7.7						1.31	10.01	13.09

Measurement Date: 5/14/2005
Location: M3 - Marsac Creek
Measurement by: KEE
Stage:
Method: 6/10
No. of Sections: 17

Rating Constants
Rev's <=40 2.2048 0.0178
Rev's >40 2.2048 0.0178

Width: 8.0 ft **Q: 3.57 cfs** **Area: 6.73 ft²** **Avg Velocity: 0.53 ft/s**
USGS STD Pygmy rating V=2.2048R+.013

	Distance	Width (ft)	Observation Depth	Depth (ft)	Revolutions	Time (sec)	Velocity (fps)	Avg Velocity (fps)	Area (sft)	Discharge (cfs)
1	2.0	0.25	0.0	0.00	0	0	0.00	0.00	0.00	0.00
1	2.5	0.50	0.6	0.70	8	60	0.31	0.31	0.35	0.11
1	3.0	0.50	0.6	0.80	14	60	0.53	0.53	0.40	0.21
1	3.5	0.50	0.6	0.90	19	60	0.72	0.72	0.45	0.32
1	4.0	0.50	0.6	1.00	20	60	0.75	0.75	0.50	0.38
1	4.5	0.50	0.6	1.10	22	60	0.83	0.83	0.55	0.46
1	5.0	0.50	0.6	1.20	16	60	0.61	0.61	0.60	0.37
1	5.5	0.50	0.6	1.15	18	60	0.68	0.68	0.58	0.39
1	6.0	0.50	0.6	1.10	20	60	0.75	0.75	0.55	0.41
1	6.5	0.50	0.6	1.10	15	60	0.57	0.57	0.55	0.31
1	7.0	0.50	0.6	1.00	16	60	0.61	0.61	0.50	0.31
1	7.5	0.50	0.6	0.90	9	60	0.35	0.35	0.45	0.16
1	8.0	0.50	0.6	0.70	4	60	0.16	0.16	0.35	0.06
1	8.5	0.50	0.6	0.70	5	60	0.20	0.20	0.35	0.07
1	9.0	0.50	0.6	0.80	0	60	0.02	0.02	0.40	0.01
1	9.5	0.50	0.6	0.30	0	60	0.02	0.02	0.15	0.00
1	10.0	0.25	0.0	0.00	0	60	0.02	0.00	0.00	0.00
	Total	8.00						0.53	6.73	3.57

Measurement Date: 5/25/2005
Location: M3 - Marsac Creek
Measurement by: KEE
Stage:
Method: 6/10
No. of Sections: 17

Rating Constants
Rev's <=40 2.2048 0.0178
Rev's >40 2.2048 0.0178

Width: 6.6 ft **Q:** 1.70 cfs **Area:** 4.48 ft² **Avg Velocity:** 0.38 ft/s
USGS STD Pygmy rating V=2.2048R+.013

	Distance	Width (ft)	Observation Depth	Depth (ft)	Revolutions	Time (sec)	Velocity (fps)	Avg Velocity (fps)	Area (sft)	Discharge (cfs)
1	1.4	0.25	0.0	0.00	0	0	0.00	0.00	0.00	0.00
1	1.9	0.50	0.6	0.50	7	60	0.28	0.28	0.25	0.07
1	2.4	0.50	0.6	0.50	8	60	0.31	0.31	0.25	0.08
1	2.9	0.50	0.6	0.50	23	60	0.86	0.86	0.25	0.22
1	3.4	0.50	0.6	0.70	17	60	0.64	0.64	0.35	0.22
1	3.9	0.50	0.6	0.80	20	60	0.75	0.75	0.40	0.30
1	4.4	0.50	0.6	0.80	23	60	0.86	0.86	0.40	0.34
1	4.9	0.50	0.6	0.90	14	60	0.53	0.53	0.45	0.24
1	5.4	0.50	0.6	1.00	6	60	0.24	0.24	0.50	0.12
1	5.9	0.50	0.6	1.00	4	60	0.16	0.16	0.50	0.08
1	6.4	0.50	0.6	0.90	0	60	0.02	0.02	0.45	0.01
1	6.9	0.50	0.6	0.80	0	60	0.02	0.02	0.40	0.01
1	7.4	0.55	0.6	0.50	0	60	0.02	0.02	0.28	0.01
1	8.0	0.30	0.6	0.00	0	60	0.02	0.02	0.00	0.00
	Total	6.60						0.38	4.48	1.70

Appendix 9: Maryland Method for Computing the Channel Protection Storage Volume

Appendix

D.11

Method for Computing the Channel Protection Storage Volume (Cp_v)

The following procedure shall be used to design the channel protection storage volume (Cp_v). The method is based on the Design Procedures for Stormwater Management Extended Detention Structures (MDE, 1987) and utilizes the NRCS, TR-55 Graphical Peak Discharge Method (USDA, 1986).

- Compute the time of concentration (t_c) and the one-year post-development runoff depth (Q_a) in inches.

- Compute the initial abstraction (I_a) [$I_a = 200/CN - 2$] and the ratio I_a/P where P is the one-year rainfall depth (see Table 2-2).

- With t_c and I_a/P, find the unit peak factor (q_u) from Figure D.11.1 and compute the one year post-development peak discharge $q_i = q_u A Q_a$ where A is the drainage in square miles.

- If $q_i \leq 2.0$ cfs, Cp_v is not required. Provide for water quality (WQ_v) and groundwater recharge (Re_v) as necessary.

- With q_u, find the ratio of outflow to inflow (q_o/q_i) for T = 24 hours from Figure D.11.2 (use T=12 hours in USE III/IV waters).

- Compute the peak outflow discharge $q_o = \frac{q_o}{q_i} \times q_i$

- With q_o/q_i, compute the ratio of storage to runoff volume (V_s/V_r).

$$\frac{V_s}{V_r} = 0.683 - 1.43\left(\frac{q_o}{q_i}\right) + 1.64\left(\frac{q_o}{q_i}\right)^2 - 0.804\left(\frac{q_o}{q_i}\right)^3$$

- Compute the extended detention storage volume $V_s = \left(\frac{V_s}{V_r}\right) \times V_r$ (note: $V_r = Q_a$);

  Convert V_s to acre-feet by $\frac{V_s}{12} \times A$, where V_s is in inches and A is in acres.

- Compute the required orifice area (A_o) for extended detention design:

$$A_o = \frac{q_o}{C\sqrt{2gh_o}} = \frac{q_o}{4.81\sqrt{h_o}}$$

  where h_o is the maximum storage depth associated with V_s.

- Determine the required maximum orifice diameter (d_o) $d_o = \sqrt{4A_o/\pi}$.

  A d_o of less than 3.0" is subject to local jurisdictional approval, and is not recommended unless an internal control for orifice protection is used (App. D.8).

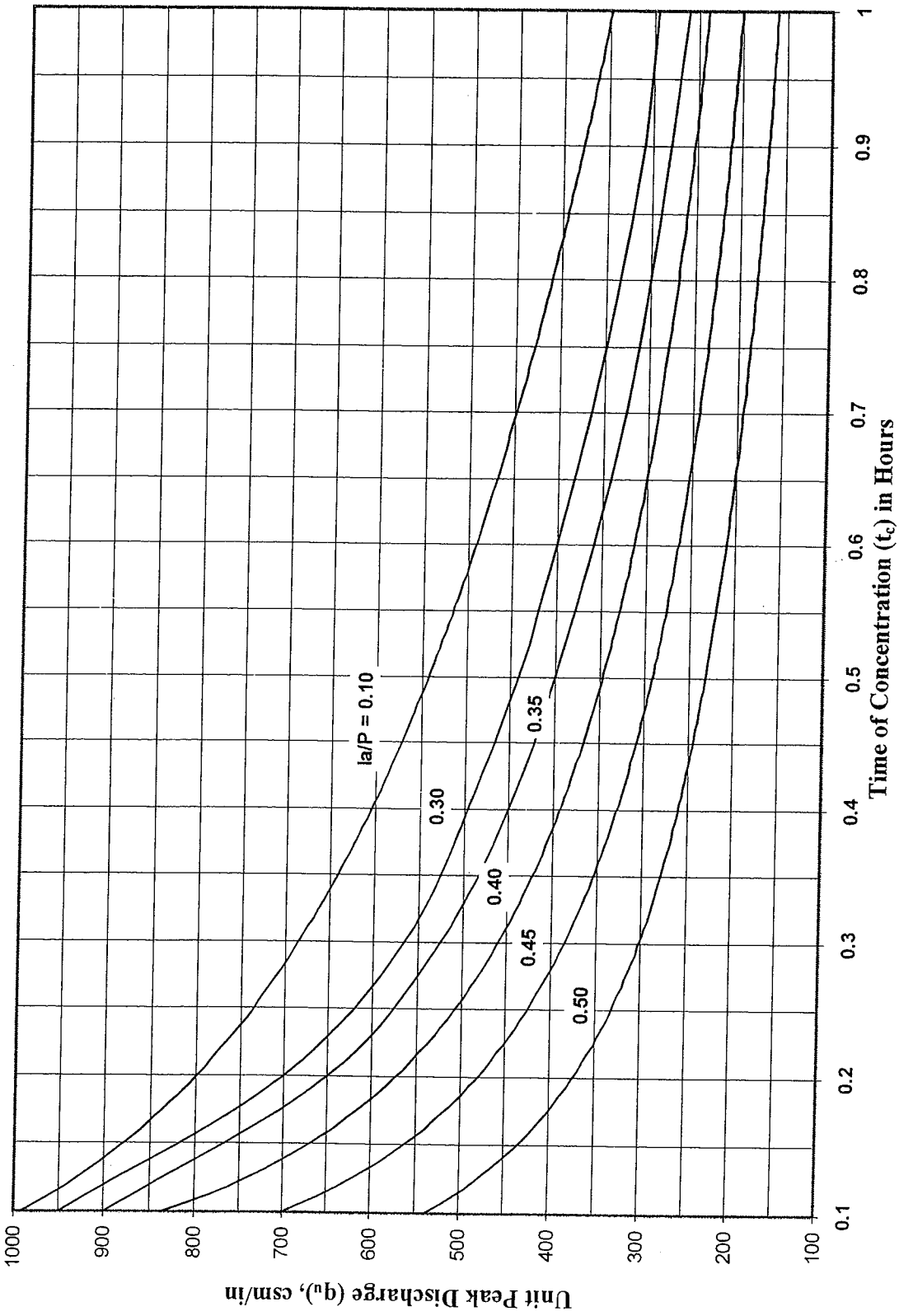
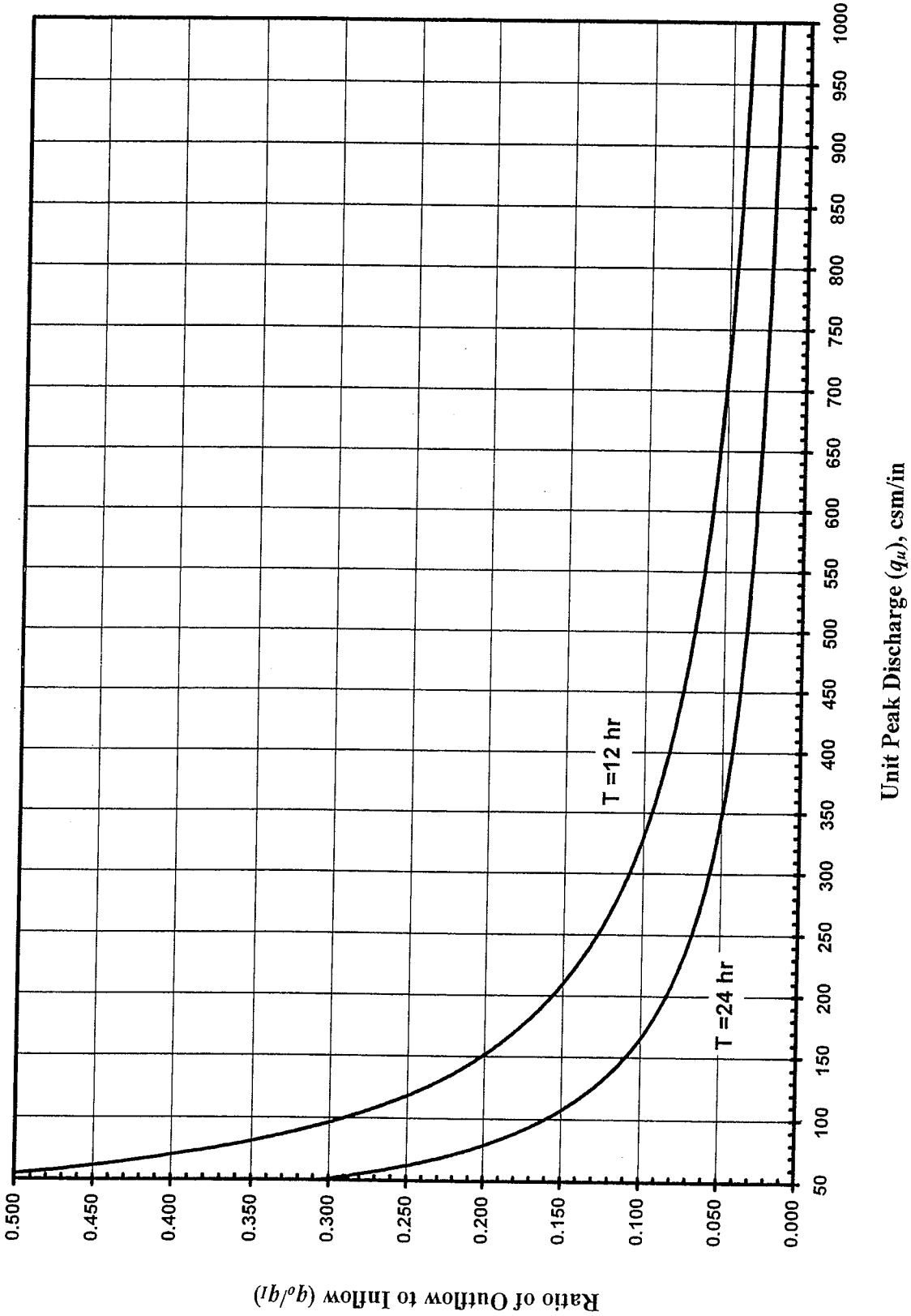


Figure D.11.1 SCS Graphical Method of Determining Peak Discharge (q_u) in csm/in for 24-Hour Type II Storm Distribution

Figure D.11.2 Detention Time Versus Discharge Ratios (q_o/q_i)



Appendix 10: Development of CN Method

APPENDIX 10: DEVELOPMENT OF CN METHOD

Streambank erosion occurs when velocities associated with channel-forming flows are given time to cause damage. The stream protection rules developed by Fishbeck, Thompson, Carr & Huber, Inc. (FTC&H) require extended detention for the 1.5-year event. This means, on average, any drop of water entering the basin will be held for a 24-hour period. The specific criterion is that the centroid of the outflow hydrograph is delayed from the centroid of the inflow hydrograph by 24 hours. By doing this, the peak discharges from the 1.5-year event are reduced to approximately predevelopment levels but, more importantly, these discharges occur over the same amount of time as they would under predevelopment conditions since they pass through the extended detention controls.

Methodology

The major problem that has to be solved is that of finding a simple rule based on easily identified site-specific parameters that, when followed, has a high likelihood of meeting the 24-hour detention time goal. The approach that was followed involves extensive sampling. Many runs were made using hydrologic modeling software (HydroCad), each with a different set of parameters. The results of these runs were used to establish a set of relationships which could then be used to establish the appropriate rules. The major challenge with this approach is to reduce the number of parameters that need to be varied to keep the task manageable and to make the derived relationships presentable. The hydrologic model (in HydroCad) is simple—a single subbasin providing flow into a single detention pond. The possible parameters that could be varied are the following:

- Drainage area, A
- Curve Number, CN
- Time of concentration, t_c
- Rainfall depth, P
- Type of unit hydrograph
- Type and duration of storm
- Shape of the detention pond
- Size of the detention pond
- Side slopes of the detention pond
- Peak depth of the detention pond
- Outlet diameter of the detention pond

There are two ways to reduce the number of parameters that need to be sampled. First, a set of reasonable assumptions can be made about several of the parameters. Second, some of the parameters can be combined into groups, allowing variation of a smaller number of parameters.

The following assumptions have been made to reduce the number of parameters:

- Use a 24-hour Soil Conservation Service (SCS) type II rainfall distribution
- Use a unit hydrograph that corresponds to observed stream behavior in Michigan. An SCS triangular unit hydrograph with 28.5% of the volume under the rising limb was used for this purpose. This is the same unit hydrograph used to generate the results published in the document *Computing Flood Discharges for Small Ungaged Watersheds* (Sorrell, 2003).
- Use a rectangular detention basin with 4:1 side slopes and peak depth (for the 1.5-year storm) of approximately 5 feet.

The parameterization follows the approach in Appendix D.11 of Maryland's Unified Stormwater Sizing Criteria. In this approach, a relationship is first developed between the Unit Peak Discharge, q_U (in cfs per mi^2 per inch of runoff), and two parameters—the time of concentration and the ratio of initial abstraction, Ia to the precipitation depth, P. This unit peak discharge is the same as Q_P given in equation 9.1 in *Computing Flood Discharges for Small Ungaged Watersheds.* (Equation 9.1 does not include the second parameter (Ia/P) because it is based on a fixed CN value of 75.) To show that the unit peak discharge can be expressed as a function of only Ia/P and t_C, consider two cases given in the table below:

Parameter	Case I	Case II
A [acre]	100	25
CN	80	66.7
P [in]	2	4
t_c [hr]	1	1
Ia [in] = .2(1000/CN-10)	0.5	1.0
Ia/P	0.25	0.25
Peak discharge [cfs]	20.14	10.31
Runoff depth [in]	0.56	1.14
Unit Peak discharge, q_U [cfs/mi^2/in]	230	231

In this example A, CN, and P are different for both cases but they produce the same Ia/P value and the same resulting unit peak discharge. No new information was, therefore, derived from running the second sample. If the unit peak discharge can be used as a key parameter in the detention basin model, then the selected sample values of A, CN, and P need only generate a complete range of Ia/P values. This greatly reduces the number of sample cases to be run.

The second relationship that is developed is that between the unit peak discharge and the ratio of peak outflow to peak inflow, q_o/q_i, for a 24-hour detention time. This simple relationship is possible since the shape of the inflow hydrograph is influenced more by the SCS rainfall distribution than the time of concentration of the drainage area. All of the inflow hydrographs will have a shape, which is quite independent of the drainage area parameters. The table below shows the results of running three examples to show that this relationship is valid. All cases use the same detention basin side slope (4:1). In each case, the detention basin base area and outlet diameter are manually adjusted to get a 24-hour detention time with a maximum depth of approximately 5 feet. All three runs use the same precipitation depth of 2 inches.

Parameter	Case A	Case B	Case C
A [acre]	640	1,280	640
CN	84	84	71
t_C [min]	30	30	15
Runoff depth [in]	0.74	0.74	0.27
Peak drainage area discharge or peak detention basin inflow, q_i [cfs]	312.5	624.9	115.1
Unit Peak Discharge, q_u [cfs/mi^2/in]	422	422	426
Detention pond base area [ac]	4	8	1.4
Outlet diameter [in]	14.5	21	8.4
Peak Detention basin outflow, q_o [cfs]	11.27	22.84	3.99
Detention outflow/inflow ratio, q_o/q_i	0.036	0.036	0.035

In this example, each case has the same unit peak discharge and results in the same detention outflow/inflow ratio.

The results of detailed sampling are shown in the data table provided as Table 1 at the end of this appendix. The detailed sampling procedure used was as follows:

- The rainfall depth was fixed at 2.06 inches. This is arbitrary as long as a range of Ia/P values is used.
- Basin side slopes were set to 4:1.
- CN values were selected to give Ia/P range from 0.05 to 0.40 (columns 2 and 3).
- t_C values were selected in the range from 15 to 480 minutes (column 4).
- The runoff depth, peak discharge, and unit peak discharge were computed from the HydroCad model (columns 5, 6, and 7).

- With the detention basin base area set to 1 acre, the drainage area (column 1) and outlet diameter (column 8) were adjusted to provide a 24-hour detention time (column 9) with a 5-foot peak pond elevation (column 10). This was easier than setting a particular, arbitrary drainage area and then adjusting the basin base area and outlet diameter.

- From these results, the peak release rate (column 11) and outflow/inflow ratio (column 13) can be computed.

- The detention storage volume (column 12) and the ratio of storage volume to inflow volume (column 13) are also computed.

Results

The two relationships described above are the primary results of this analysis. The first is the unit peak discharge (column 7) given as a function of time of concentration (column 4) and Ia/P (column 3). This is shown graphically in Figure 1.

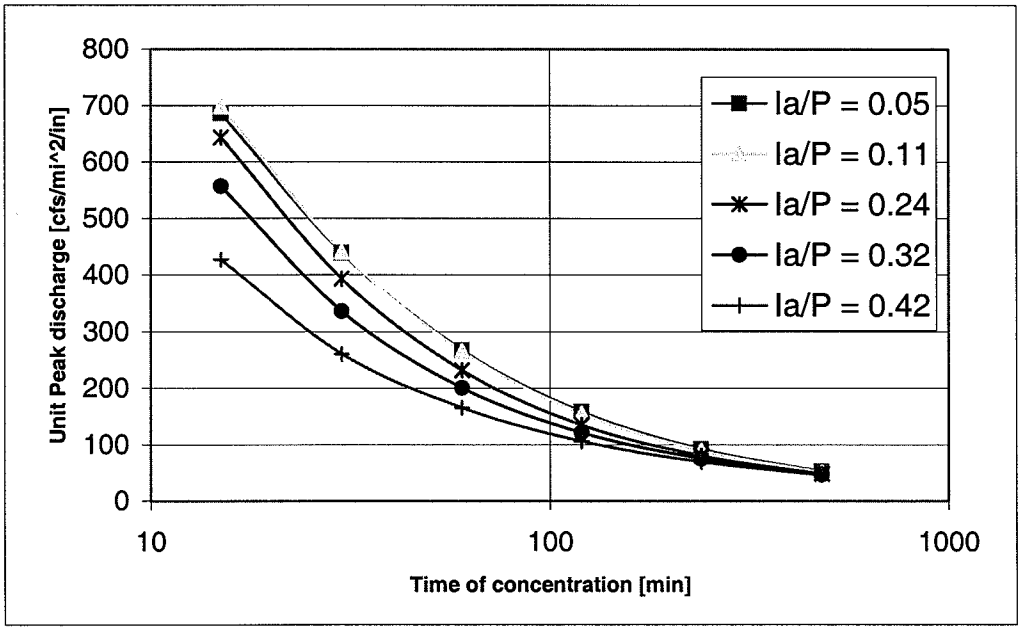


Figure 1 Unit Peak Discharge Related to Ia/P and Time of Concentration

The second relationship is that between unit peak discharge (column 7) and the detention basin outflow/inflow ratio needed to obtain a 24-hour detention time (column 13). This is indicated in figure 2.

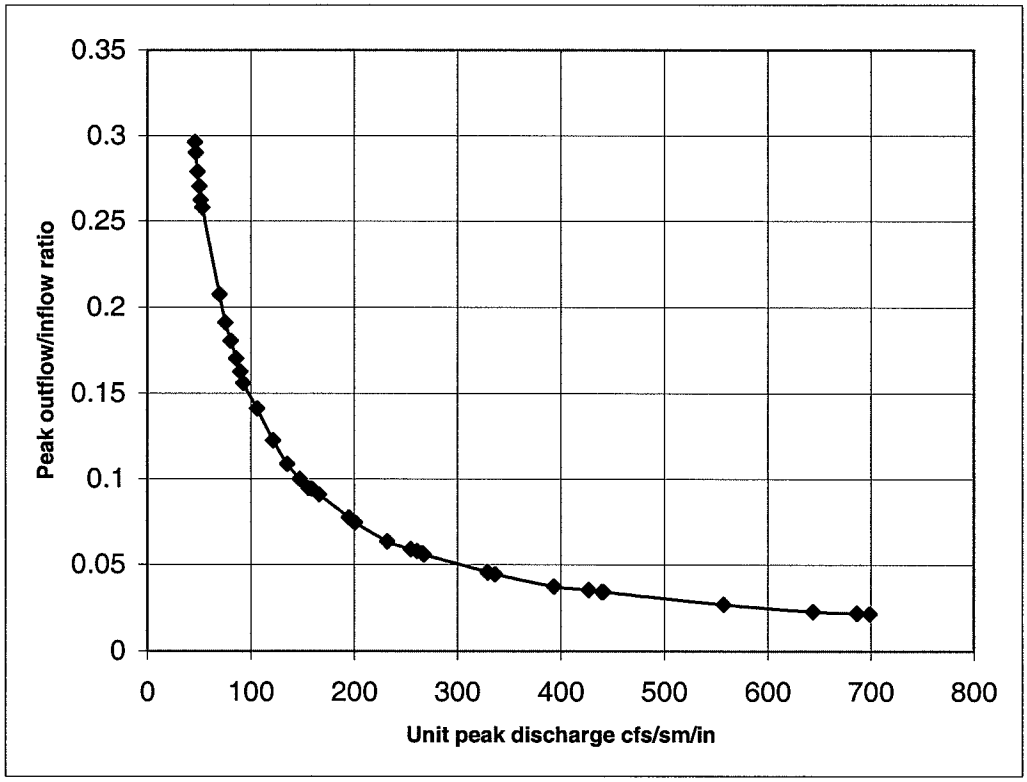


Figure 2 Peak Outflow/Inflow as a Function of Unit Peak Discharge

These two relationships can also be combined as indicated in Figure 3.

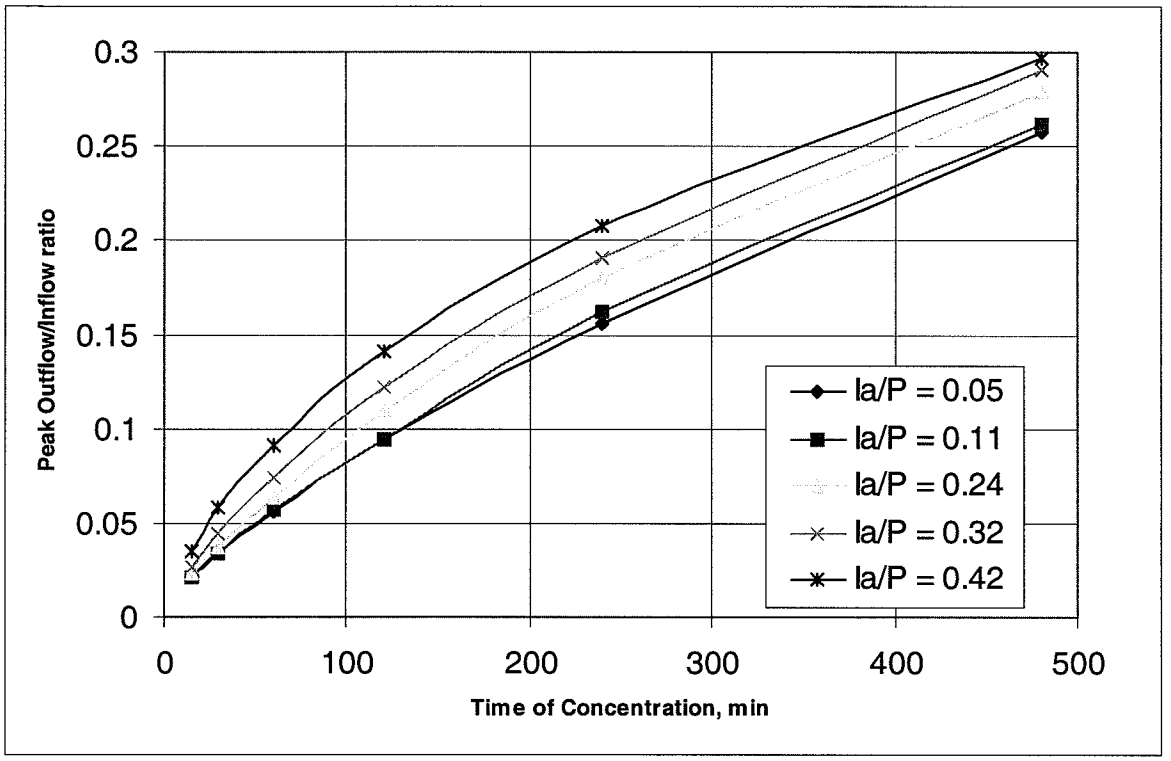


Figure 3 Peak Inflow/Outflow as a Function of Ia/P and Time of Concentration

Results Applied to Michigan Zone 8

Figures 1 and 2 could easily be used together to size a detention basin outlet for streambank protection. The procedures that would be followed are outlined in Appendix D.11 of the *Maryland Stormwater Design Manual*. A simpler method was desired for the county storm water design criteria that used a simple discharge release rate restriction.

Table 2 indicates the results of the release rate analysis applied to Michigan, Zone 8 from Illinois State Water Survey, Bulletin 71 (Huff & Angel, 1992). Columns 1 through 5 are the results of the sampling described above. They are the tabular version of Figures 1 and 2. These data can be considered generic for Michigan, since they are based on a typical Michigan unit hydrograph. Column 6 (column 1 times 2.2 in) is the initial abstraction associated with the 1.5-year rainfall event in Michigan, Zone 8. Column 7 is the CN associated with that initial abstraction value (Ia=0.2*(1000/CN-10)). Column 8 is the runoff depth associated with the CN in column 7 and the 2.2 in rainfall. Column 9 is the peak discharge (per acre) from the drainage area. This is also the peak inflow rate into the detention basin. It is computed by multiplying the Unit Peak Discharge (column 3) by the runoff depth (column 8) times 1/640 (1 acre in mi^2). Column 10 is the release rate in cfs/acre. It is column 9 times column 4. Column 11 gives the required detention

storage in ft^3/acre. It is computed as the runoff depth in feet (column 8 divided by 12) times 43,560 ft^2 times the storage volume to runoff volume ratio (column 5).

It can be seen that using a 24-hour detention of the 1.5-year event as the basis for stream protection results in a very wide range of values in columns 10 and 11. For the range of Ia/P and t_C values used in this analysis, this release rate varies over 6.5 orders of magnitude from 0.006 to 0.039 cfs per acre. Selecting a single value would be difficult to do. To be able to select a release criterion that has less variability requires incorporating more parameters. One approach would be to simply use the developed CN as an additional parameter. The values in column 10 and 11 vary only a small amount for any particular CN value. Averaging the release rates and storage volumes for each CN value results in the relationships shown in Figure 4.

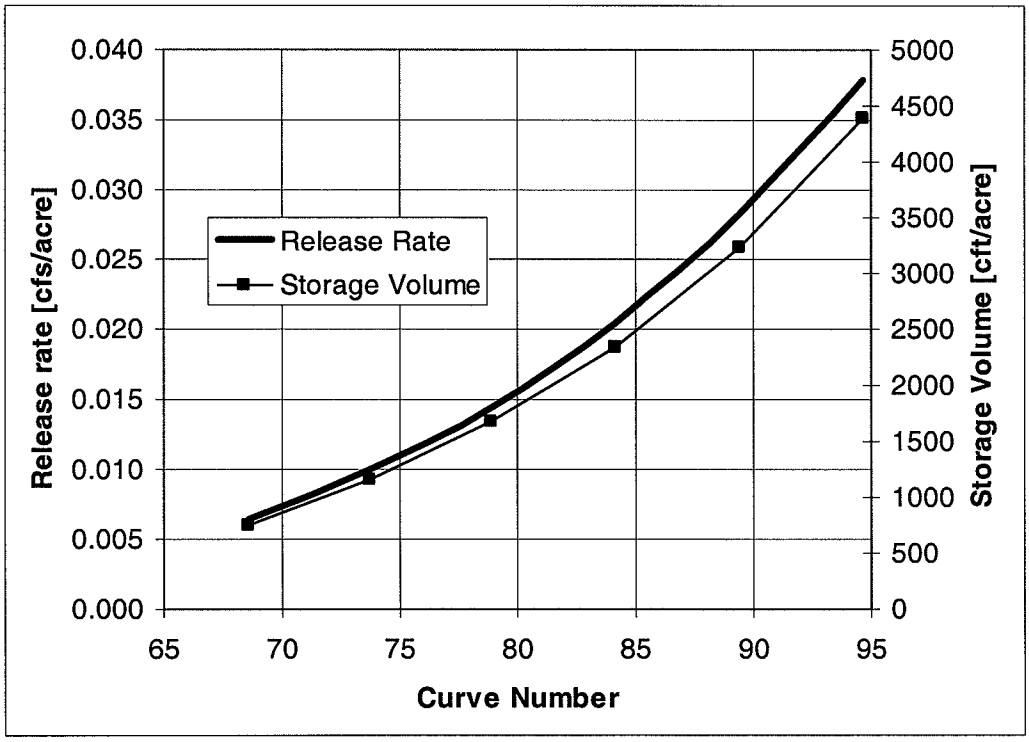


Figure 4 Release Rate as a Function of Curve Number

Another, somewhat simpler, approach does not require the developer to compute the CN. It is based on the hydrologic soil group and the imperviousness of the drainage area. Additional columns are now needed in Table 2. Columns 12 through 15 are the impervious fraction for development for the four different hydrologic soil groups. This assumes that the CN in column 7 is a weighted average of 98 for the impervious part, and the value associated with open space in good condition. So, if the soil is in hydrologic soil group B, the impervious fraction needs to 0.91 to get an average CN of 95 (row 1). By

dividing column 10 by the impervious fractions in columns 12 through 15, the release rate is recomputed in terms of cfs per impervious acres (columns 16 through 19). The values in each of these columns vary less than those in column 10. This same process was done for the detention storage volume, resulting in the values in columns 20 through 23, which are now in ft^3/impervious acre for each soil type.

A recommended value can now be determined for each hydrologic soil group using an average from each column. The results are as follows:

- HSG A: Release 0.026 cfs/impervious acre, Volume 3,000 ft^3/impervious acre
- HSG B: Release 0.034 cfs/impervious acre, Volume 4,000 ft^3/impervious acre
- HSG C: Release 0.051 cfs/impervious acre, Volume 5,800 ft^3/impervious acre
- HSG D: Release 0.059 cfs/impervious acre, Volume 5,800 ft^3/impervious acre

If it is assumed that infiltration will be used for type A and B soils, then a reasonable value for C and D soils is 0.05 cfs/impervious acre and 5,800 ft^3/impervious acre.

Table 1 – Sampling Data and Calculations

Drainage Area Inputs				Drainage Area Output			Reservoir Input	Reservoir Output				Calculations	
Area [acre] (1)	CN (2)	Ia/P (3)	Time of concentration tc [min] (4)	Runoff depth [in] (5)	Peak discharge qi [cfs] (6)	Unit peak discharge, qu [cfs/mi^2/in] (7)	Orifice diameter [in] (8)	Detention time [min] (9)	Maximum depth [ft] (10)	Peak release, qo [cfs] (11)	Storage Volume, Vs [ac-ft] (12)	Peak outflow to inflow ratio qo/qi (13)	Storage volume to runoff volume ratio, Vs/Vr (14)
80	95	0.051	15	1.54	132.18	687	7.1	1455	5.05	2.89	7.65	0.022	0.745
80	95	0.051	30	1.54	84.55	439	7.1	1454	5.05	2.89	7.65	0.034	0.745
80	95	0.051	45	1.54	63.42	329	7.1	1453	5.04	2.88	7.64	0.045	0.744
80	95	0.051	60	1.54	51.53	268	7.1	1451	5.04	2.88	7.63	0.056	0.743
80	95	0.051	90	1.54	38.17	198	7.1	1447	5.03	2.88	7.62	0.075	0.742
80	95	0.051	120	1.54	30.57	159	7.1	1443	5.01	2.88	7.59	0.094	0.739
80	95	0.051	240	1.54	17.83	93	7	1462	4.97	2.78	7.52	0.156	0.732
80	95	0.051	480	1.54	10.19	53	6.9	1454	4.71	2.63	7.14	0.258	0.695
110	90	0.108	15	1.15	138.11	699	7.2	1435	5.11	2.99	7.74	0.022	0.734
110	90	0.108	30	1.15	87.16	441	7.2	1433	5.11	2.98	7.74	0.034	0.734
110	90	0.108	45	1.15	65.08	329	7.2	1431	5.1	2.98	7.73	0.046	0.733
110	90	0.108	60	1.15	52.51	266	7.2	1429	5.09	2.98	7.72	0.057	0.732
110	90	0.108	90	1.15	38.48	195	7.2	1425	5.08	2.98	7.69	0.077	0.729
110	90	0.108	120	1.15	30.68	155	7.1	1457	5.09	2.9	7.71	0.095	0.731
110	90	0.108	240	1.15	17.71	90	7.1	1436	5.02	2.88	7.6	0.163	0.721
110	90	0.108	480	1.15	10.14	51	6.9	1467	4.83	2.66	7.31	0.262	0.693
150	85	0.171	15	0.84	135.08	686	7.2	1431	5.06	2.97	7.74	0.022	0.737
150	85	0.171	60	0.84	50.15	255	7.2	1425	5.04	2.96	7.64	0.059	0.728
150	85	0.171	120	0.84	28.93	147	7.1	1453	5.05	2.89	7.65	0.100	0.729
150	85	0.171	240	0.84	16.86	86	7.1	1432	4.99	2.87	7.56	0.170	0.720
150	85	0.171	480	0.84	9.84	50	6.9	1464	4.81	2.66	7.28	0.270	0.693
210	80	0.243	15	0.6	126.75	644	7.1	1462	5.1	2.9	7.72	0.023	0.735
210	80	0.243	30	0.6	77.43	393	7.1	1461		2.9	7.71	0.037	0.734
210	80	0.243	60	0.6	45.66	232	7.1	1457		2.9	7.7	0.064	0.733
210	80	0.243	120	0.6	26.58	135	7.1	1448		2.89	7.65	0.109	0.729
210	80	0.243	240	0.6	15.85	81	7.1	1428	4.97	2.86	7.54	0.180	0.718
210	80	0.243	480	0.6	9.5	48	6.9	1462	4.78	2.65	7.25	0.279	0.690
300	75	0.324	15	0.41	107.09	557	7.1	1442	5.02	2.88	7.6	0.027	0.741
300	75	0.324	30	0.41	64.6	336	7.1	1440	5.01	2.87	7.59	0.044	0.740
300	75	0.324	60	0.41	38.58	201	7.1	1437	4.99	2.87	7.59	0.074	0.740
300	75	0.324	120	0.41	23.28	121	7.1	1429	4.95	2.85	7.49	0.122	0.731
300	75	0.324	240	0.41	14.44	75	7	1449	4.89	2.76	7.41	0.191	0.723
300	75	0.324	480	0.41	9	47	6.9	1445		2.61	7.04	0.290	0.687
450	70	0.416	15	0.26	77.99	427	7	1448	4.9	2.76	7.42	0.035	0.761
450	70	0.416	30	0.26	47.66	261	7	1447	4.89	2.76	7.4	0.058	0.759
450	70	0.416	60	0.26	30.29	166	7	1444	4.86	2.75	7.37	0.091	0.756
450	70	0.416	120	0.26	19.35	106	7	1437	4.81	2.73	7.28	0.141	0.747
450	70	0.416	240	0.26	12.72	70	6.9	1459	4.73	2.64	7.17	0.208	0.735
450	70	0.416	480	0.26	8.37	46	6.8	1457	4.47	2.48	6.77	0.296	0.694

Table 2 – Allegan County Data

Results from Sampling (see Table 1)					Values Based on Michigan Zone 8, 1.5 Year Rainfall: P=2.2 in						Impervious Fraction				Release Rate [cfs/imp acre]				Storage Volume [ft^3/imp acre]			
Ia/P (1)	Time of concentration, tc [min] (2)	Unit peak discharge, qu [cfs/mi^2/in] (3)	Peak outflow to inflow ratio qo/qi (4)	Storage volume to runoff volume ratio, Vs/Vr (5)	Initial abstraction, Ia [in] (6)	CN (7)	Runoff depth, [in] (8)	Peak detention basin inflow, qi [cfs/acre] (9)	Peak detention basin outflow, qo [cfs/acre] (10)	Detention storage [ft^3/acre] (11)	HSG A Open CN=39 (12)	HSG B Open CN=61 (13)	HSG C Open CN=74 (14)	HSG D Open, CN=80 (15)	HSG A (16)	HSG B (17)	HSG C (18)	HSG D (19)	HSG A (20)	HSG B (21)	HSG C (22)	HSG D (23)
0.051	15	686.6	0.022	0.745	0.112	95	1.64	1.76	0.039	4449	0.94	0.91	0.86	0.82	0.041	0.042	0.045	0.047	4714	4887	5163	5455
0.051	30	439.2	0.034	0.745	0.112	95	1.64	1.13	0.039	4449	0.94	0.91	0.86	0.82	0.041	0.042	0.045	0.047	4714	4887	5163	5455
0.051	45	329.5	0.045	0.744	0.112	95	1.64	0.85	0.038	4443	0.94	0.91	0.86	0.82	0.041	0.042	0.045	0.047	4708	4881	5157	5448
0.051	60	267.7	0.056	0.743	0.112	95	1.64	0.69	0.038	4437	0.94	0.91	0.86	0.82	0.041	0.042	0.045	0.047	4702	4875	5150	5441
0.051	90	198.3	0.075	0.742	0.112	95	1.64	0.51	0.038	4431	0.94	0.91	0.86	0.82	0.041	0.042	0.045	0.047	4696	4868	5143	5434
0.051	120	158.8	0.094	0.739	0.112	95	1.64	0.41	0.038	4414	0.94	0.91	0.86	0.82	0.041	0.042	0.045	0.047	4677	4849	5123	5413
0.051	240	92.6	0.156	0.732	0.112	95	1.64	0.24	0.037	4373	0.94	0.91	0.86	0.82	0.039	0.041	0.043	0.046	4634	4804	5076	5363
0.051	480	52.9	0.258	0.695	0.112	95	1.64	0.14	0.035	4152	0.94	0.91	0.86	0.82	0.037	0.039	0.041	0.043	4400	4562	4819	5092
0.108	15	698.7	0.022	0.734	0.237	89	1.22	1.34	0.029	3260	0.85	0.77	0.64	0.52	0.034	0.038	0.045	0.055	3817	4248	5083	6248
0.108	30	441.0	0.034	0.734	0.237	89	1.22	0.84	0.029	3260	0.85	0.77	0.64	0.52	0.034	0.038	0.045	0.055	3817	4248	5083	6248
0.108	45	329.3	0.046	0.733	0.237	89	1.22	0.63	0.029	3256	0.85	0.77	0.64	0.52	0.034	0.038	0.045	0.055	3812	4243	5076	6240
0.108	60	265.7	0.057	0.732	0.237	89	1.22	0.51	0.029	3252	0.85	0.77	0.64	0.52	0.034	0.038	0.045	0.055	3807	4237	5070	6231
0.108	90	194.7	0.077	0.729	0.237	89	1.22	0.37	0.029	3239	0.85	0.77	0.64	0.52	0.034	0.038	0.045	0.055	3792	4221	5050	6207
0.108	120	155.2	0.095	0.731	0.237	89	1.22	0.30	0.028	3247	0.85	0.77	0.64	0.52	0.033	0.037	0.044	0.054	3802	4232	5063	6223
0.108	240	89.6	0.163	0.721	0.237	89	1.22	0.17	0.028	3201	0.85	0.77	0.64	0.52	0.033	0.036	0.043	0.053	3748	4172	4991	6135
0.108	480	51.3	0.262	0.693	0.237	89	1.22	0.10	0.026	3079	0.85	0.77	0.64	0.52	0.030	0.034	0.040	0.049	3605	4012	4801	5901
0.171	15	686.1	0.022	0.737	0.377	84	0.90	0.96	0.021	2399	0.77	0.63	0.42	0.23	0.028	0.034	0.050	0.092	3135	3835	5676	
0.171	60	254.7	0.059	0.728	0.377	84	0.90	0.36	0.021	2368	0.77	0.63	0.42	0.23	0.028	0.034	0.050	0.092	3094	3785	5603	
0.171	120	146.9	0.100	0.729	0.377	84	0.90	0.21	0.021	2371	0.77	0.63	0.42	0.23	0.027	0.033	0.049	0.089	3098	3790	5610	
0.171	240	85.6	0.170	0.720	0.377	84	0.90	0.12	0.020	2343	0.77	0.63	0.42	0.23	0.027	0.033	0.048	0.089	3062	3746	5544	
0.171	480	50.0	0.270	0.693	0.377	84	0.90	0.07	0.019	2256	0.77	0.63	0.42	0.23	0.025	0.030	0.045	0.082	2949	3607	5339	
0.243	15	643.8	0.023	0.735	0.534	79	0.64	0.64	0.015	1708	0.68	0.48	0.21		0.022	0.030	0.072		2525	3526	8322	
0.243	30	393.3	0.037	0.734	0.534	79	0.64	0.39	0.015	1706	0.68	0.48	0.21		0.022	0.030	0.072		2521	3522	8311	
0.243	60	231.9	0.064	0.733	0.534	79	0.64	0.23	0.015	1704	0.68	0.48	0.21		0.022	0.030	0.072		2518	3517	8300	
0.243	120	135.0	0.109	0.729	0.534	79	0.64	0.14	0.015	1693	0.68	0.48	0.21		0.022	0.030	0.072		2502	3494	8246	
0.243	240	80.5	0.180	0.718	0.534	79	0.64	0.08	0.015	1669	0.68	0.48	0.21		0.021	0.030	0.071		2466	3444	8128	
0.243	480	48.3	0.279	0.690	0.534	79	0.64	0.05	0.013	1604	0.68	0.48	0.21		0.020	0.028	0.066		2371	3311	7815	
0.324	15	557.2	0.027	0.741	0.712	74	0.44	0.38	0.010	1181	0.59	0.34			0.017	0.030			2005	3427		
0.324	30	336.1	0.044	0.740	0.712	74	0.44	0.23	0.010	1179	0.59	0.34			0.017	0.030			2002	3422		
0.324	60	200.7	0.074	0.740	0.712	74	0.44	0.14	0.010	1179	0.59	0.34			0.017	0.030			2002	3422		
0.324	120	121.1	0.122	0.731	0.712	74	0.44	0.08	0.010	1164	0.59	0.34			0.017	0.030			1976	3377		
0.324	240	75.1	0.191	0.723	0.712	74	0.44	0.05	0.010	1151	0.59	0.34			0.017	0.029			1955	3341		
0.324	480	46.8	0.290	0.687	0.712	74	0.44	0.03	0.009	1094	0.59	0.34			0.016	0.027			1857	3174		
0.416	15	426.6	0.035	0.761	0.915	69	0.28	0.19	0.007	778	0.50	0.21			0.013	0.032			1550	3786		
0.416	30	260.7	0.058	0.759	0.915	69	0.28	0.11	0.007	776	0.50	0.21			0.013	0.032			1546	3775		
0.416	60	165.7	0.091	0.756	0.915	69	0.28	0.07	0.007	772	0.50	0.21			0.013	0.032			1540	3760		
0.416	120	105.8	0.141	0.747	0.915	69	0.28	0.05	0.007	763	0.50	0.21			0.013	0.032			1521	3714		
0.416	240	69.6	0.208	0.735	0.915	69	0.28	0.03	0.006	752	0.50	0.21			0.013	0.031			1498	3658		
0.416	480	45.8	0.296	0.694	0.915	69	0.28	0.02	0.006	710	0.50	0.21			0.012	0.029			1414	3454		

Appendix 11: Work Index Derivation

APPENDIX 11: WORK INDEX DERIVATION

For uniform flow in a stream channel, the shearing stress, τ, can be computed as $\tau = \gamma R s_0$ where γ is the unit weight of the water, R is the hydraulic radius, and s_0 is the channel slope. (The hydraulic radius is the flow area divided by wetted perimeter, which, for a wide rectangular channel, is just the flow depth.) Streambanks tend to erode when the shear stress exceeds some critical value, τ_c, often referred to as the critical shear stress for bed mobility. The erosive power per unit area of stream bank is $P = (\tau - \tau_c)V$ where V is the stream velocity. The erosive work is the erosive power integrated (or added up) over the time $W = \int_{time} P dt = \int (\gamma R s_0 - \tau_c) V dt$. (Some sources indicate that it is appropriate to raise the term in brackets to a power between 1 and 2.5.) The critical shear stress can be determined based on soil properties. An alternative method is to write this equation in terms of a critical hydraulic radius for bed mobility, R_c. The critical shear can then be computed as $\tau_c = \gamma R_c s_0$. When this is substituted into the equation for erosive work, the following results:

$$W = \gamma s_0 \int_{time} (R - R_c) V dt .$$

Since the unit weight of water and channel slope are not affected by the detention policy, an effective measure of the impact of channel-forming flows is the Work Index, $W' = \int_{time} (R - R_c) V dt.$

Appendix 12: Build Out Analysis - ISAT Parameter Reports and Intensity Class Codes

MACOMB COUNTY FUTURE LAND USE - DEVELOPMENT INTENSITY CLASS CODES

CHESTERFIELD TWP FUTURE LAND USE

Land_Use	LU_CLASS
GENERAL COMMERCIAL	HIGH INTENSITY
GENERAL INDUSTRIAL	HIGH INTENSITY
LIGHT INDUSTRIAL	HIGH INTENSITY
LOCAL COMMERCIAL	HIGH INTENSITY
LOW DENSITY	LOW INTENSITY
MANUFACTURED HOUSING COMMUNITY	HIGH INTENSITY
MEDIUM DENSITY	HIGH INTENSITY
MEDIUM LOW DENSITY	LOW INTENSITY
MODERATE DENSITY	HIGH INTENSITY
MODERATE LOW DENSITY	LOW INTENSITY
MULTIPLE-FAMILY HIGH DENSITY	HIGH INTENSITY
MULTIPLE-FAMILY LOW DENSITY	HIGH INTENSITY
MULTIPLE-FAMILY MEDIUM DENSITY	HIGH INTENSITY
OFFICE	HIGH INTENSITY
RURAL AND ESTATE	LOW INTENSITY

CLINTON TWP FUTURE LAND USE

Land_Use	LU_CLASS
COMMERCIAL	HIGH INTENSITY
FLOODWAY	BELOW
INDUSTRIAL	HIGH INTENSITY
MULTIPLE FAMILY RESIDENTIAL	HIGH INTENSITY
PUBLIC/ QUASI-PUBLIC	LOW INTENSITY
SINGLE FAMILY RESIDENTIAL	LOW INTENSITY

HARRISON TWP FUTURE LAND USE

Land_Use	LU_CLASS
CONVENIENCE COMMERCIAL	HIGH INTENSITY
GENERAL COMMERCIAL	HIGH INTENSITY
LIGHT INDUSTRIAL	HIGH INTENSITY
MARINA	HIGH INTENSITY
MEDIUM RESIDENTIAL	HIGH INTENSITY
PUBLIC	LOW INTENSITY

LENOX TWP FUTURE LAND USE

Land_Use	LU_CLASS
AGRICULTURAL CAMPUS	BELOW
EDUCATIONAL CAMPUS	HIGH INTENSITY
GOVERNMENT CENTER	HIGH INTENSITY
HIGH DENSITY RESIDENTIAL	HIGH INTENSITY
HIGHWAY BUSINESS	HIGH INTENSITY
INTENSIVE IMPACT	HIGH INTENSITY
LIGHT INDUSTRIAL	HIGH INTENSITY
LOCAL BUSINESS	HIGH INTENSITY
LOW DENSITY RESIDENTIAL	LOW INTENSITY
MEDIUM DENSITY RESIDENTIAL	HIGH INTENSITY
MOBILE HOME PARK	HIGH INTENSITY
OFFICE CENTER	HIGH INTENSITY
OFFICE WAREHOUSE	HIGH INTENSITY
OPEN SPACE	LOW INTENSITY
PLANNED NEIGHBORHOOD	HIGH INTENSITY
PUBLIC SERVICE	HIGH INTENSITY
RECREATION	LOW INTENSITY
RESEARCH & DEVELOPMENT CAMPUS	HIGH INTENSITY
RURAL PRESERVATION	LOW INTENSITY
TOWN CENTER MIXED USE	HIGH INTENSITY
TOWN CENTER RETAIL CORE	HIGH INTENSITY
UTILITY	HIGH INTENSITY

MACOMB TWP FUTURE LAND USE

Land_Use	LU_CLASS
COMMERCIAL	HIGH INTENSITY
EDISON SUBSTATION	HIGH INTENSITY
INDUSTRIAL (HEAVY)	HIGH INTENSITY
INDUSTRIAL (LIGHT)	HIGH INTENSITY
PUBLIC SCHOOL	HIGH INTENSITY
RESIDENTIAL (ONE UNIT PER ACRE)	LOW INTENSITY
RESIDENTIAL (SIX UNITS PER ACRE)	HIGH INTENSITY
RESIDENTIAL (THREE UNITS PER ACRE)	LOW INTENSITY
TOWNSHIP PROPERTY	LOW INTENSITY

NEW BALTIMORE CITY FUTURE LAND USE

Land_Use	LU_CLASS
CENTRAL BUSINESS	HIGH INTENSITY
COMMERCIAL	HIGH INTENSITY
HEAVY INDUSTRIAL	HIGH INTENSITY
LIGHT INDUSTRIAL	HIGH INTENSITY
LOCAL COMMERCIAL	HIGH INTENSITY
MANUFACTURED HOUSING COMMUNITY	HIGH INTENSITY
MODERATE DENSITY RESIDENTIAL	HIGH INTENSITY
MULTIPLE FAMILY	HIGH INTENSITY
PUBLIC/PARK	LOW INTENSITY
RESIDENTIAL	HIGH INTENSITY
WATERFRONT MARINA RESIDENTIAL	HIGH INTENSITY
WATERFRONT RESIDENTIAL	HIGH INTENSITY

NEW HAVEN VILLAGE FUTURE LAND USE

Land_Use	LU_CLASS
CLUSTER RESIDENTIAL	HIGH INTENSITY
COMMUNITY FACILITIES	HIGH INTENSITY
GENERAL BUSINESS	HIGH INTENSITY
GENERAL INDUSTRIAL	HIGH INTENSITY
MOBILE HOME RESIDENTIAL	HIGH INTENSITY
MULTIPLE-FAMILY RESIDENTIAL	HIGH INTENSITY
RECREATION AND OPEN SPACE	BELOW
RESTRICTED INDUSTRIAL	HIGH INTENSITY
SINGLE-FAMILY RESIDENTIAL	LOW INTENSITY

RICHMOND CITY FUTURE LAND USE

Land_Use	LU_CLASS
HIGH DENSITY SINGLE FAMILY RESIDENTIAL	HIGH INTENSITY
HIGHWAY COMMERCIAL	HIGH INTENSITY
HISTORIC COMMERCIAL	HIGH INTENSITY
INDUSTRIAL	HIGH INTENSITY
LOW DENSITY SINGLE FAMILY RESIDENTIAL	LOW INTENSITY
MEDIUM DENSITY SINGLE FAMILY RESIDENTIAL	HIGH INTENSITY
MIXED RESIDENTIAL	HIGH INTENSITY
MOBILE HOME	HIGH INTENSITY
MULTIPLE FAMILY RESIDENTIAL	HIGH INTENSITY
NEIGHBORHOOD COMMERCIAL	HIGH INTENSITY
OFFICE	HIGH INTENSITY
PLANNED MULTIPLE FAMILY RESIDENTIAL	HIGH INTENSITY
PLANNED SINGLE FAMILY RESIDENTIAL	HIGH INTENSITY
PUBLIC/ SEMI-PUBLIC	BELOW
RIGHT-OF WAY	HIGH INTENSITY
RIGHT-OF-WAY	HIGH INTENSITY

RICHMOND TWP FUTURE LAND USE

Land_Use	LU_CLASS
COMMERCIAL	HIGH INTENSITY
INDUSTRIAL	HIGH INTENSITY
LOW DENSITY RESIDENTIAL	LOW INTENSITY
OFFICE/LOCAL COMMERCIAL	HIGH INTENSITY
PRIMARY AGRICULTURAL	BELOW
SECONDARY AGRICULTURAL	BELOW
URBAN RESIDENTIAL	HIGH INTENSITY

ST CLAIR COUNTY FUTURE LAND USE - DEVELOPMENT INTENSITY CLASS CODES
Low- low intensity/High-high intensity/Below- less than low intensity/Outside- outside watershed

UNITTEXT	Cnt_UNIT	GENCLASS
	67	Low
4-Square Hunt Club	1	Outside
Agricultural	40	Outside
Agricultural / Residential	18	Outside
Agricultural / Residential Estate	4	Outside
Agricultural and Rural Residential	6	Outside
Agricultural/Rural Residential	1	Outside
Agriculture	3	Outside
Agriculture & Rural Residential	19	Below
Agriculture / Low Density Residential	3	Outside
Agriculture / Rural Residential	4	Outside
Agriculture and Rural Residential	10	Below
Agrucultural and Rural Residential	25	Outside
Airport	2	High
Area in which to locate 20-40 acre Lt. Indus. Park	9	Outside
Area in which to locate 2nd township park	1	Outside
Bluewater Gateway Business	1	Outside
Boy Scout Camp	1	Outside
Burt Road Industrial Area	1	Outside
Center Commercial	4	Outside
Central Business District	9	High
Civic / Community	4	High
Comercial	8	High
Commercial	122	High
Commercial & Office	12	High
Commercial / Office	16	Outside
Commercial Core	2	Outside
Commercial Vehicular	3	Outside
Community Center	2	High
Community Facilities	10	Outside
Community Park	5	Outside
Community Service Area	1	Outside
Conservation/Open Space	6	Outside
Convenience Commercial	3	High
Corridor Commercial	8	Outside
DATA ERROR	7	Outside
Data Error	2	Outside
Downtown	4	Outside
Downtown District	2	Outside
Downtown Residential	7	Outside
Dunnigan/Kinney Commercial Area	1	Outside
Exsisting Recreation Site	1	Outside
Flood Hazard	12	Outside
Flood Plain	11	Below
Freeway Corridor	2	Outside
Future Township Park	4	Outside
General Commercial	8	High
General Industrial	4	Outside
Green Buffer	3	Outside
Green Space	3	Outside
Heavy Industrial	11	Outside
High Density Residential	11	Outside
High Tech. Industrial	1	Outside
Highway Commercial	1	Outside
Industrial	40	High
Industrial Park	6	Outside
Industrial Research Office	1	Outside
Industry	7	Outside
Institutional	11	Outside
Light Industrial	40	Low
Light Industrial & Research	3	Outside
Light Industrial Park	2	High
Local Business	4	High
Local Commercial	10	Outside
Local Institution	71	Outside
Low Density Residential	18	Outside
Low Density Single Family Residential	12	Outside
Low Intensity Industrial	1	Outside
Low-Density Residential	2	Outside
Main Street Commercial Area	1	Outside
Manufactured Home Park	4	High
Manufactured Housing	3	Outside
Marina-Residential	1	Low
Marinas	7	High
Medical Campus	1	Outside
Medium Density Residential	12	Outside
Medium Density Single Family Residential	3	Outside
Medium-Density Residential	1	Outside
Mobile Home	4	Outside
Mobile Home Park	9	High
Mobile Home Parks	1	Outside
Moderate Density Residential	8	High
Multi-Family Residential	4	Outside
Multiple Dwelling	1	Outside
Multiple Family	18	High
Multiple Family / Mixed Use	4	High
Multiple Family Residential	25	High
Multiple Residential	8	Outside
Multiple-Family Residential	38	Outside
Natural Area	1	Outside
Neighborhood Business	8	Outside
Neighborhood Commercial	9	Outside
Neighborhood Residential	61	Outside
Neighborhood Services	7	High
Non Buildable	5	Outside
Non-Buildable	7	Outside

UNITTEXT	Cnt_UNIT	GENCLASS
Office	13	Outside
Office Center	1	Low
Office Service	3	Low
Open Space	111	Below
Open Space Corridor	2	Outside
Open Space, Conservation, Recreation	7	Below
Open Space/Conservation	2	Outside
Park/Recreation/Public Facilities	8	Outside
Parks	8	Below
Parks & Recreation	45	Outside
Pine Grove Mixed Use	7	Outside
Planned Unit Development	1	Outside
Planned Waterfront	4	High
Prime Agriculture	3	Outside
Professional Office	1	Outside
Proposed Roads	55	Outside
Public	3	Low
Public & Quasi Public	1	Outside
Public & Semi-Public	9	Outside
Public / Quasi-Public	4	Outside
Public / Semi-Public	9	Low
Public School	1	Outside
Public, Quasi-Public, Institutional	36	Outside
Public, Quasi_Public, Institutional	10	Outside
Public,Quasi-Public,Institutional	14	Outside
Public/Quasi-Public	19	Outside
Public/Quasi-Public/Institutional	12	Outside
Public/Semi-Public	17	Low
Railroad Industrial Area	1	Outside
Recreation	49	Low
Recreation & Open Space	5	Outside
Recreation / Conservation	2	Outside
Recreation / Open Space	1	Outside
Recreation, Conservation, Open Space	2	Outside
Recreation/Conservation	196	Low
Recreation/Open Space	3	Outside
Regional Business	4	Outside
Regional Office	5	Outside
Residential	12	Outside
Residential (Low Density)	4	Outside
Residential (Medium Density)	5	Outside
Residential / Agricultural	9	Outside
Residential Acreage	2	Low
Residential Multiple	4	Outside
Residential Suburban	2	Low
Residential Suburban 2	2	Low
Residential Suburban Farms	9	Outside
River Conservation	4	Outside
Road	9	Outside
Road Right of Way	44	Outside
Roads	6	Outside
Rural / Conservation	5	Low
Rural Estate	4	Outside
Rural Residential	10	Low
Rural Residential Area	4	Outside
Sand and Gravel	2	Outside
School	1	Outside
Schools	5	Outside
Sensitive & Open Space	1	Outside
Sensitive & Recreation	1	Outside
Sensitive Area	5	Outside
Shopping Center	1	High
Sinfle-Family Attached Residential	4	Outside
Single Family	23	High
Single Family Residential	159	Low
Single Family Residential-Waterfront	8	High
Single-Family Residential	169	Outside
Special Project Area	1	Outside
Special Purpose	3	Outside
State Game Area	2	Outside
State Park	2	Below
Suburban - Low Density	4	Low
Suburban Density Residential	6	Outside
Suburban Farm	3	Outside
Suburban Residential	7	Low
Township Hall	1	Outside
Township Offices	1	Outside
Two-Family Residential	22	Outside
Urban - Moderate Density	7	High
Urban Residential	25	Outside
Utility	1	Outside
Utility / Agriculture	3	Below
Utility / Flood	3	Outside
Utility / Open Space	3	Below
Utility Use	4	Outside
Utiliy / Residential	1	Low
Very Low Density Residential/Conservation/Open Space	2	Outside
Very Low Density Rural Residential	4	Outside
Village Core	1	Outside
Village Residential	1	Outside
Village Residential Area	3	Outside
Water	5	Outside
Waterfront Parks	3	Below
Waterfront Residential	8	Low

Impervious surface analysis run: Thursday March 17, 2005 02:19:02 PM

Output Layer Name: anchorbay_exlu_calccoef

Land Cover Layer: gl_2001_migeo
Land Cover Grid Units: Meters

Analysis Layer: anchorbay_lakestclair_union
Analysis Field: SHED_ID

Coefficient Option
Population coefficient was identified using the value of the POPDENS field within the bg2000_099_147v4b theme.
High >= 2500
Medium between 2500 and 250
Low <= 250

Coefficients:(Value,ClassName,High,Medium,Low)
1,Unclassified,0,0,0
2,High Intensity Developed,59.5,39.1,30.2
3,Low Intensity Developed,41.3,30.2,22.9
4,Cultivated Land,14.7,8.7,3.6
5,Grassland,14.9,9.9,5.7
6,Deciduous Forest,3.9,4.9,2.1
7,Evergreen Forest,3.9,4.9,2.1
8,Mixed Forest,3.9,4.9,2.1
9,Scrub/Shrub,3.9,4.9,2.1
10,Palustrine Forested Wetland,22.1,3.5,3
11,Palustrine Scrub/Shub Wetland,22.1,3.5,3
12,Palustrine Emergent Wetland,0,0,0
13,Estuarine Forested Wetland,22.1,3.5,3
14,Estuarine Scrub/Shrub Wetland,22.1,3.5,3
15,Estuarine Emergent Wetland,0,0,0
16,Unconsolidated Shore,1,1,1
17,Bare Land,18.6,42.4,11.8
18,Water,0,0,0
19,Palustrine Aquatic Bed,0,0,0
20,Estuarine Aquatic Bed,0,0,0
21,Tundra,0,0,0
22,Snow/Ice,0,0,0
0,Unknown,0,0,0

Impervious surface analysis run: Thursday March 31, 2005 03:02:18 PM

Output Layer Name: blockgroup_exlu_calccoef

Land Cover Layer: 2001 LAND COVER
Land Cover Grid Units: Meters

Analysis Layer: bg2000_subsheds
Analysis Field: LINK

Coefficient Option
Population coefficient was identified using the value of the POPDENS field within the BLOCK GROUP POP/SQMI theme.
High >= 2500
Medium between 2500 and 250
Low <= 250

Coefficients:(Value,ClassName,High,Medium,Low)
1,Unclassified,0,0,0
2,High Intensity Developed,59.5,39.1,30.2
3,Low Intensity Developed,41.3,30.2,22.9
4,Cultivated Land,14.7,8.7,3.6
5,Grassland,14.9,9.9,5.7
6,Deciduous Forest,3.9,4.9,2.1
7,Evergreen Forest,3.9,4.9,2.1
8,Mixed Forest,3.9,4.9,2.1
9,Scrub/Shrub,3.9,4.9,2.1
10,Palustrine Forested Wetland,22.1,3.5,3
11,Palustrine Scrub/Shub Wetland,22.1,3.5,3
12,Palustrine Emergent Wetland,0,0,0
13,Estuarine Forested Wetland,22.1,3.5,3
14,Estuarine Scrub/Shrub Wetland,22.1,3.5,3
15,Estuarine Emergent Wetland,0,0,0
16,Unconsolidated Shore,1,1,1
17,Bare Land,18.6,42.4,11.8
18,Water,0,0,0
19,Palustrine Aquatic Bed,0,0,0
0,unknown,0,0,0

Impervious surface analysis run: Tuesday May 10, 2005 01:57:24 PM

Output Layer Name: anchorbay_flu_calccoef

Land Cover Layer: 2001 LAND COVER
Land Cover Grid Units: Meters

Analysis Layer: ANCHOR BAY SUB SHEDS
Analysis Field: SHED_ID

Coefficient Option
Population coefficient was identified using the value of the POPDENS field within the BLOCK GROUP POP/SQMI theme.
High >= 2500
Medium between 2500 and 250
Low <= 250

Coefficients: (Value,ClassName,High,Medium,Low)
1,Unclassified,0,0,0
2,High Intensity Developed,59.5,39.1,30.2
3,Low Intensity Developed,41.3,30.2,22.9
4,Cultivated Land,14.7,8.7,3.6
5,Grassland,14.9,9.9,5.7
6,Deciduous Forest,3.9,4.9,2.1
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9,Scrub/Shrub,3.9,4.9,2.1
10,Palustrine Forested Wetland,22.1,3.5,3
11,Palustrine Scrub/Shub Wetland,22.1,3.5,3
12,Palustrine Emergent Wetland,0,0,0
13,Estuarine Forested Wetland,22.1,3.5,3
14,Estuarine Scrub/Shrub Wetland,22.1,3.5,3
15,Estuarine Emergent Wetland,0,0,0
16,Unconsolidated Shore,1,1,1
17,Bare Land,18.6,42.4,11.8
18,Water,0,0,0
19,Palustrine Aquatic Bed,0,0,0
0,unknown,0,0,0

Change Scenarios
Changed land cover classes within FLU HIGH INTENSITY layer to High Intensity Developed
Changed land cover classes within FLU LOW INTENSITY layer to Low Intensity Developed

Impervious surface analysis run: Tuesday May 10, 2005 02:19:55 PM

Output Layer Name: blockgroup_flu_calccoef

Land Cover Layer: 2001 LAND COVER
Land Cover Grid Units: Meters

Analysis Layer: bg2000_subsheds
Analysis Field: LINK

Coefficient Option
Population coefficient was identified using the value of the POPDENS field within the BLOCK GROUP POP/SQMI theme.
High >= 2500
Medium between 2500 and 250
Low <= 250

Coefficients:(Value,ClassName,High,Medium,Low)
1,Unclassified,0,0,0
2,High Intensity Developed,59.5,39.1,30.2
3,Low Intensity Developed,41.3,30.2,22.9
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9,Scrub/Shrub,3.9,4.9,2.1
10,Palustrine Forested Wetland,22.1,3.5,3
11,Palustrine Scrub/Shub Wetland,22.1,3.5,3
12,Palustrine Emergent Wetland,0,0,0
13,Estuarine Forested Wetland,22.1,3.5,3
14,Estuarine Scrub/Shrub Wetland,22.1,3.5,3
15,Estuarine Emergent Wetland,0,0,0
16,Unconsolidated Shore,1,1,1
17,Bare Land,18.6,42.4,11.8
18,Water,0,0,0
19,Palustrine Aquatic Bed,0,0,0
0,unknown,0,0,0

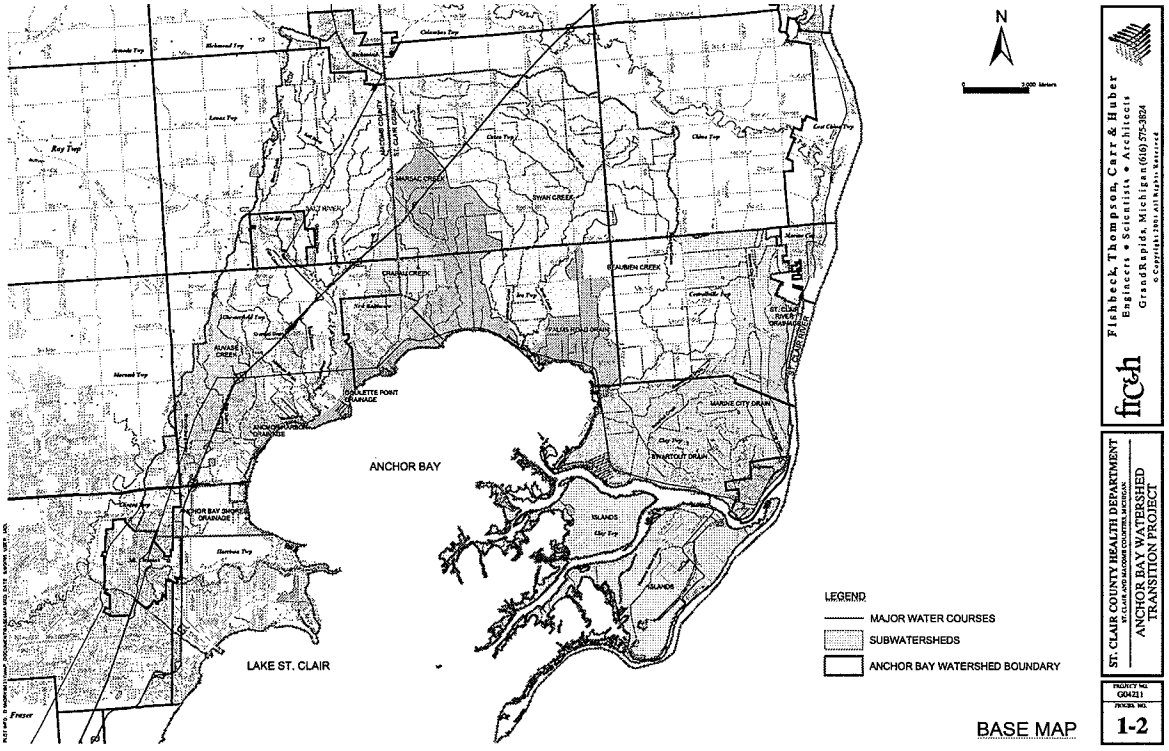
Change Scenarios
Changed land cover classes within FLU HIGH INTENSITY layer to High Intensity Developed
Changed land cover classes within FLU LOW INTENSITY layer to Low Intensity Developed

Appendix 13: Draft Model Storm Water Ordinance for Anchor Bay Watershed Communities

DRAFT MODEL STORM WATER ORDINANCE

FOR

ANCHOR BAY WATERSHED COMMUNITIES



June 2005

fishbeck, thompson, carr & huber
engineers • scientists • architects

J:\04211\REPT\APP13_ANCHORBAYMODELSWORDINANCE.DOC

_____ of _____
County of St. Clair or Macomb, Michigan

AN ORDINANCE to provide for the protection of the environment against pollution from storm water runoff; to provide flood control and adequate drainage; to provide for the regulation and control of storm water runoff; to provide for storm water permits and the procedures and standards for the issuance thereof; to provide for payment or reimbursement of costs and expenses incurred by the **Township/Municipality** associated with storm water permits and the consideration thereof; to establish standards and requirements for the protection of the environment and for the control of soil erosion and sedimentation; to adopt other provisions for the establishing, maintaining and protection of drains and drainage ways; to provide regulations for the inspection, sampling and monitoring of storm water and other discharges; to require long-term maintenance and financial assurance; to establish performance and design standards for storm water management in specified zones of the **Township/Municipality**; to provide for the severability of this ordinance; and to provide penalties for violations of the ordinance.

THE _____ OF _____ ORDAINS:

Article I - General

Sec. 1.01 Statutory Authority and Title

[For a General Law Township:]

This ordinance is adopted in accordance with the Township Ordinance Act, as amended, being MCL 41.181, et seq.; the Township and Village Public Improvement Act, as amended, being MCL 41.721, et seq.; the Drain Code of 1956, as amended, being MCL 280.1, et seq.; the Land Division Act, as amended, being MCL 560.1, et seq.; the Revenue Bond Act, as amended, being MCL 141.101, et seq.; the Natural Resources and Environmental Protection Act, as amended, being MCL 324.101, et seq.; Section 401(p) of the Federal Water Pollution Control Act (also known as the Clean Water Act), as amended, being 33 USC 1342(p) and 40 CFR Parts 9, 122, 123 and 124; and other applicable state and federal laws.

[For a Charter Township:]

This ordinance is adopted in accordance with the Charter Township Act, as amended, being MCL 42.1, et seq.; the Township and Village Public Improvement Act, as amended, being MCL 41.721, et seq.; the Drain Code of 1956, as amended, being MCL 280.1, et seq.; the Land Division Act, as amended, being MCL 560.1, et seq.; the Revenue Bond Act, as amended, being MCL 141.101, et seq.; and the Natural Resources and Environmental Protection Act, as amended, being MCL 324.101, et seq.; Section 401(p) of the Federal Water Pollution Control Act (also known as the Clean Water Act), as amended, being 33 USC 1342(p) and 40 CFR Parts 9, 122, 123 and 124; and other applicable state and federal laws.

[For a Home Rule City:]

This ordinance is adopted in accordance with the Home Rule City Act, as amended, being MCL 117.1, et seq.; the Drain Code of 1956, as amended, being MCL 280.1, et seq.; the Land Division Act, as amended, being MCL 560.1, et seq.; the Revenue Bond Act, as amended, being MCL 141.101, et seq.; and the Natural Resources and Environmental Protection Act, as amended, being MCL 324.101, et seq.; Section 401(p) of the Federal Water Pollution Control Act (also known as the Clean Water Act), as amended, being 33 USC 1342(p) and 40 CFR Parts 9, 122, 123 and 124; and other applicable state and federal laws.

[For a General Law Village:]

This ordinance is adopted in accordance with the Incorporation of Villages Act, as amended, being MCL 61.1, et seq.; the Township and Village Public Improvement Act, as amended, being MCL 41.721, et seq.; the Drain Code of 1956, as amended, being MCL 280.1, et seq.; the Land Division Act, as amended, being MCL 560.1, et seq.; the Revenue Bond Act, as amended, being MCL 141.101, et seq.; and the Natural Resources and Environmental Protection Act, as amended, being MCL 324.101, et seq.; Section 401(p) of the Federal Water Pollution Control Act (also known as the Clean Water Act), as amended, being 33 USC 1342(p) and 40 CFR Parts 9, 122, 123 and 124; and other applicable state and federal laws.

[For a Charter Village:]

This ordinance is adopted in accordance with the Home Rule Village Act, as amended, being MCL 78.1, et seq.; the Township and Village Public Improvement Act, as amended, being MCL 41.721, et seq.; the Drain Code of 1956, as amended, being MCL 280.1, et seq.; the Land Division Act, as amended, being MCL 560.1, et seq.; the Revenue Bond Act, as amended, being MCL 141.101, et seq.; and the Natural Resources and Environmental Protection Act, as amended, being MCL 324.101, et seq.; Section 401 (p) of the Federal Water Pollution Control Act (also known as the Clean Water Act), as amended, being 33 USC 1342(p) and 40 CFR Parts 9, 122, 123 and 124; and other applicable state and federal laws.

This ordinance shall be known and may be cited as the _____ of _____ Storm Water Ordinance.

Sec. 1.02 Findings

The **Township/Municipality** finds that:

(1) Waterbodies, roadways, structures, and other property within and downstream of the **Township/Municipality** are at times subjected to flooding;
(2) Flooding is a danger to the lives and property of the public and is also a danger to the natural resources of the **Township/Municipality** and the region;
(3) Land development alters the hydrologic response of watersheds, resulting in increased storm water runoff rates and volumes, increased flooding, increased stream channel erosion, and increased sediment transport and deposition;
(4) Storm water runoff produced by land development contributes to increased quantities of waterborne pollutants;
(5) Increases of storm water runoff, soil erosion, and non-point source pollution have occurred as a result of land development, and cause deterioration of the water resources of the **Township/Municipality** and downstream municipalities;
(6) Storm water runoff, soil erosion, and non-point source pollution, due to land development within the **Township/Municipality**, have resulted in a deterioration of the water resources of the **Township/Municipality** and downstream municipalities;
(7) Increased storm water runoff rates and volumes, and the sediments and pollutants associated with storm water runoff from future development projects within the **Township/Municipality** will, absent reasonable regulation and control, adversely affect the **Township/Municipality's** waterbodies and water resources, and those of downstream municipalities;
(8) Storm water runoff, soil erosion, and non-point source pollution can be controlled and minimized by the regulation of storm water runoff from development;
(9) Illicit discharges contain pollutants that will significantly degrade the waterbodies and water resources of the **Township/Municipality**, thus threatening the health, safety and welfare of the citizenry;

(10) Illicit discharges enter the storm water drainage system through either direct connections (e.g., wastewater piping either mistakenly or deliberately connected to the storm drains) or indirect connections (e.g., infiltration into the storm drain system or spills collected by drain inlets);
(11) Establishing the measures for controlling illicit discharges and connections contained in this Ordinance and implementing the same will address many of the deleterious effects of illicit discharges;
(12) Any condition caused or permitted to exist in violation of any of the provisions of this Ordinance is a threat to public health, safety and welfare, and is declared and deemed a nuisance;
(13) Adopting the standards, criteria and procedures contained in this ordinance and implementing the same will address many of the deleterious effects of storm water runoff; and
(14) Adopting these standards is necessary for the preservation of the public health, safety and welfare.

Sec. 1.03 Purpose

It is the purpose of this ordinance to establish minimum storm water management requirements and controls to accomplish, among others, the following objectives:

(1) To protect the environment against pollution and other effects from storm water runoff, and to protect the public health and safety;
(2) To reduce artificially induced flood damage;
(3) To minimize increased storm water runoff rates and volumes from identified new land development;
(4) To minimize the deterioration of existing watercourses, culverts and bridges, and other structures;
(5) To encourage water recharge into the ground where geologically favorable conditions exist;
(6) To minimize the impact of development upon stream bank and streambed stability;
(7) To reduce erosion from development or construction projects;
(8) To prevent an increase in non-point source pollution;
(9) To regulate the contribution of pollutants to the storm water drainage system and waterbodies by storm water discharges by any user;
(10) To prohibit illicit discharges and connections to the storm water drainage system and waterbodies;
(11) To reduce storm water runoff rates and volumes, soil erosion and non-point source pollution, wherever practicable, from lands that were developed without storm water management controls meeting the purposes and standards of this ordinance;
(12) To reduce the adverse impact of changing land use on waterbodies and, to that end, this ordinance establishes minimum standards to protect waterbodies from degradation resulting from changing land use where there are insufficient storm water management controls;

(13) To maintain the integrity of stream channels for their biological functions, as well as for drainage and other purposes;
(14) To preserve and protect water supply facilities and water resources by means of controlling increased flood discharges, stream erosion and runoff pollution;
(15) To establish legal authority to carry out all inspection, surveillance and monitoring procedures necessary to ensure compliance with this Ordinance; and
(16) To provide appropriate remedies for failure to comply with this Ordinance.

Sec. 1.04 Applicability, Exemptions and General Provisions

(1) Articles I, II, III, VII, VIII and IX of this ordinance shall apply to any development site which requires approval of a plat, a site development plan, building permit or any other permit for work which will alter storm water drainage characteristics of the development site, provided, however, that this ordinance shall not apply to the following:
  (a) The installation or removal of individual mobile homes within a mobile home park. This exemption shall not be construed to apply to the construction, expansion or modification of a mobile home park.
  (b) Farm operations and buildings, except dwellings, directly related to farm operations. This exemption shall not apply to greenhouses and other similar structures.
  (c) Plats with preliminary plat approval and other developments with final land use approval prior to the effective date of this ordinance, where such approvals remain in effect.
(2) Articles I, IV, V, VI and IX of this ordinance shall apply to all discharges entering the storm water drainage system and waterbodies generated on any developed and undeveloped lands.

Sec. 1.05 Definitions

For the purpose of this ordinance, the following words and phrases shall have the meanings respectively ascribed to them by this Section unless the context in which they are used specifically indicates otherwise:

(1) Authorized Enforcement Agency – The **Township/Municipality**, and/or any persons or agencies designated to act as the Authorized Enforcement Agency by the **Township/Municipality**.
(2) Bank Full Discharge – A condition where flow completely fills the stream channel to the top of the bank. In undisturbed watersheds, this occurs on average every 1.5 to 2 years and controls the shape and form of natural channels.
(3) Base Flood – A flood having a one (1) percent chance of being equaled or exceeded in any given year.
(4) Base Flood Elevation – The high water elevation of the Base Flood commonly referred to as the "100-year flood elevation."

(5) Best Management Practices (BMPs) – Structural devices or nonstructural practices that are designed to prevent pollutants from entering into storm water flows, to direct the flow of storm water or to treat polluted storm water flows. BMPs are often classified as either nonstructural and/or structural. Nonstructural BMPs are preventative actions that involve management and source controls. Examples include: buffer preservation along waterbodies; establishment of easements for vegetative filters and infiltration; education programs for developers and the public about project designs that minimize water quality and quantity impacts; minimum disturbance of soils and vegetation; planting native vegetation; restrictions on directly connected impervious areas; and incentives for reducing imperviousness. Structural BMPs are physical controls that improve water quality, including storage practices. Examples of structural BMPs include: wet ponds and extended-detention outlet structures; vegetative buffers; filtration practices such as grassed swales, sand filters and filter strips; and infiltration practices such as infiltration basins, infiltration trenches, rain gardens and infiltration islands in parking lots.

(6) Buffer Strip – A vegetated surface that is designed or protected to treat sheet flow from adjacent surfaces. It functions by slowing runoff velocity and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. ***Not used again.***

(7) Building Opening – Any opening of a solid wall such as a window or door, through which floodwaters could penetrate.

(8) Clean Water Act – The Federal Water Pollution Control Act, 33 USC Sec 1251 et seq., as amended, and the applicable regulations promulgated thereunder.

(9) Construction Site Storm Water Runoff – Storm water runoff from a development site following an earth change.

(10) Detention – A system which is designed to capture storm water and release it over a given period of time through an outlet structure at a controlled rate.

(11) Developed or Development – The installation or construction of impervious surfaces on a development site that require, pursuant to state law or local ordinance, the **Township/Municipality's** approval of a site plan, plat, site condominium, special land use, planned unit development, rezoning of land, land division approval, private road approval or other approvals required for the development of land or the erection of buildings or structures; provided, however, that for purposes of Article II only, developed or development shall not include the actual construction of, or an addition, extension or modification to, an individual single-family or a two-family detached dwelling.

(12) Developer – Any person proposing or implementing the development of land.

(13) Development Site – Any land that is being or has been developed, or that a property owner proposes for development.

(14) Discharge – means the introduction (intentionally or unintentionally, and directly or indirectly) of any liquid, substance, pollutant, or other material into a storm water drainage system or water body.

(15) Discharger – Any person or entity who directly or indirectly discharges storm water from any property. Discharger also means any employee, officer, director, partner, contractor, or other person who participates in, or is legally or factually

responsible for, any act or omission which is or results in a violation of this ordinance.

(16) Drain – Any and all conduits, facilities, measures, areas, and structures that serve to convey, catch, hold, filter, store and/or receive storm water or groundwater, either on a temporary or permanent basis.

(17) Drainage – The collection, conveyance or discharge of groundwater and/or surface water.

(18) Drainageway – A drain, water body or floodplain.

(19) Earth Change – Any human activity which removes ground cover, changes the slope or contours of the land or exposes the soil surface to the actions of wind and rain. Earth change includes, but is not limited to, any excavating, surface grading, filling, landscaping or removal of vegetative roots.

(20) EPA – The United States Environmental Protection Agency.

(21) Erosion – The process by which the ground surface is worn away by action of wind, water, gravity or a combination thereof.

(22) First Flush – The delivery of a highly concentrated pollutant loading during the early stages of a storm, due to the washing effect of runoff on pollutants that have accumulated on the land.

(23) Flood or Flooding – A general and temporary condition of partial or complete inundation of normally dry land areas resulting from the overflow of waterbodies or the unusual and rapid accumulation of surface water runoff from any source.

(24) Floodplain – Any land area subject to periodic flooding.

(25) Flood Protection Elevation (FPE) – The Base Flood Elevation plus one (1) foot at any given location.

(26) Floodway – The channel of any watercourse and the adjacent land areas that must be reserved to carry and discharge a base flood without cumulatively increasing the water surface elevation more than one-tenth (1/10) of a foot due to the loss of flood conveyance or storage.

(27) Grading – Any stripping, excavating, filling and stockpiling of soil or any combination thereof and the land in its excavated or filled condition.

(28) Hazardous Materials – Any solid, liquid, semisolid or gaseous substance or material that because of its quantity, quality, concentration or physical, chemical or infectious characteristics may cause or significantly contribute to an increase in mortality or an increase in serious irreversible illness or serious incapacitating but reversible illness, or may pose a substantial present or potential hazard to human health or the environment if improperly treated, stored, transported, disposed of or otherwise managed.

(29) Illicit Connection – Any method, means or conduit for conveying an illicit discharge into a water body or a storm water drainage system.

(30) Illicit Discharge – Any discharge to a water body or a storm water drainage system that does not consist entirely of storm water, that is not authorized by the terms of an NPDES permit or that is not an authorized discharge as defined by this Ordinance.

(31) Impervious Surface – Surface that does not allow storm water runoff to infiltrate.

(32) Non-Storm Water Discharge – Any discharge to the storm water drainage system or a water body that is not composed entirely of storm water.
(33) NPDES – National Pollution Discharge Elimination System.
(34) Overland Flow-way – Surface area that conveys a concentrated flow of storm water runoff.
(35) Person – An individual, firm, partnership, association, public or private corporation, public agency, instrumentality or any other legal entity.
(36) Plan – Written narratives, specifications, drawings, sketches, written standards, operating procedures or any combination of these which contain information pursuant to this ordinance.
(37) Pollutant – The term pollutant includes, but is not limited to, the following: any dredged spoil, solid waste, vehicle fluids, yard wastes, animal wastes, agricultural waste products, sediment, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological wastes, radioactive materials, hazardous materials, wrecked or discharged equipment, rock, sand, cellar dirt, and industrial, municipal, commercial, and agricultural waste, or any other contaminant or other substance defined as a pollutant under the Clean Water Act. Pollutant also includes properties or characteristics of water, including, but not limited to, pH, heat, total suspended solids (TSS), turbidity, color, biochemical oxygen demand (BOD), chemical oxygen demand (COD), toxicity and odor.
(38) Premises – Any building, structure, lot, parcel of land or portion of land or property, whether improved or unimproved, including adjacent sidewalks and parking strips.
(39) Property Owner – Any person having legal or equitable title to property or that person's designee.
(40) Retention – A system which is designed to capture storm water and contain it until it infiltrates into the soil or evaporates.
(41) Soil Erosion – The stripping of soil and weathered rock from land creating sediment for transportation by water, wind or ice, and enabling formation of new sedimentary deposits.
(42) State of Michigan Water Quality Standards – All applicable State rules, regulations, and laws pertaining to water quality, including the provisions of Section 3106 of Part 31 of 1994 PA 451, as amended.
(43) Storm Drain – A system of open or enclosed conduits and appurtenant structures intended to convey or manage storm water runoff, groundwater and drainage.
(44) Storm Water Drainage System – Storm sewers, conduits, curbs, gutters, catch basins, drains, ditches, pumping devices, parking lots, roads or other man-made channels that are designed or used, singly or together in combination with one another, for collecting or conveying storm water.
(45) Storm Water Permit – A permit issued pursuant to this ordinance.
(46) Storm Water Pollution Prevention Plan – A document that describes the BMPs and activities to be implemented by a person or business to identify sources of pollution or contamination at a site and the actions to eliminate or

reduce pollutant discharges to storm water, a storm water drainage system and/or a water body to the maximum extent practicable.

(47) Storm Water Runoff – The runoff and drainage of precipitation resulting from rainfall or snowmelt or other natural event or process.

(48) Storm Water Runoff Facility – The method, structure, area, system or other equipment or measures which are designed to receive, control, store or convey storm water.

(49) Stream – A river, stream or creek which may or may not be serving as a drain, or any other waterbody that has definite banks, a bed and visible evidence of a continued flow or continued occurrence of water.

(50) **Township/Municipality** – The City/Township/Charter Township/Village of _____.

(51) Toxic Material – Any pollutant or combination of pollutants that is or can potentially be harmful to the public health or the environment, including, without limitation, those listed in 40 CFR 401.15 as toxic under the provisions of the Clean Water Act, or listed in the Critical Materials Register promulgated by the Michigan Department of Environmental Quality, or as otherwise provided by local, state or federal laws, rules or regulations.

(52) Wastewater – Any water or other liquid, other than uncontaminated storm water, discharged from premises. The term includes any water that has in any way been used and degraded or physically or chemically altered.

(53) Waterbody – A river, lake, stream, creek or other watercourse or wetlands.

(54) Watershed – A region draining into a waterbody.

(55) Wetlands – Land characterized by the presence of water at a frequency and duration sufficient to support wetland vegetation or aquatic life.

Article II – Storm Water Permits

Sec. 2.01 Permit Required

(1) A property owner shall not engage in any development without first receiving a storm water permit from the Township/Municipality pursuant to Section 2.02.

(2) The granting of a storm water permit shall authorize only such development for which the permit is issued, subject to the terms of the permit, and it shall not be deemed to approve other development or other land use activities.

Sec. 2.02 Storm Water Permit Review Procedures

The **Township/Municipality** shall grant a storm water permit, which may impose terms and conditions in accordance with Section 2.09, and which shall be granted only upon compliance with each of the following requirements:

(1) The property owner has submitted a drainage plan complying with Section 2.03.

(2) The property owner has satisfied the requirements of Section 2.05 for construction site runoff controls.

(3) The property owner provides a sealed statement by a Licensed Professional Engineer in the State of Michigan that one of the following conditions is satisfied:

(a) Storm water will be discharged to an adequate outlet through a permanent onsite storm water system sufficient to discharge storm water generated by the 100-year storm event without onsite property damage; or

(b) The property owner provides a permanent onsite storm water system with a restricted outlet designed to result in no net increase in storm water runoff volume or rate onto any adjacent property (or wetlands) in a 100-year storm event. In keeping with Common Law Natural Flow Rights, concentrated discharges of storm water (such as from a storm water management system) or increased surface water runoff over property owned by others must be pursuant to a valid right-of-way, easement or other written permission from all property owners affected.

(4) The property owner has paid or deposited the storm water permit review fee pursuant to Section 2.04.

(5) The property owner has paid or posted the applicable financial guarantee pursuant to Section 2.06.

(6) The property owner provided all easements necessary to implement the approved drainage plan and to otherwise comply with this Ordinance including, but not limited to, Section 7.02. All easements are acceptable to the **Township/Municipality** in form and substance and are recorded with the county Register of Deeds.

(7) The drainage plan has been designed in conformity with the **Township/Municipality's** Performance and Design Standards for drains and storm water management systems, as set forth in Article VIII.

(8) All storm water runoff facilities have been designed to include appropriate BMPs.

(9) The property owner provided the required maintenance agreement for routine, emergency, and long-term maintenance of all storm water runoff facilities. The maintenance agreement is in compliance with the approved drainage plan and this Ordinance including, but not limited to, Section 7.03. The maintenance agreement is acceptable to the **Township/Municipality** in form and substance and has been recorded with the county Register of Deeds.

Sec. 2.03 Drainage Plan.

The property owner shall provide a drainage plan to the **Township/Municipality** for review and approval by the **Township/Municipality**. The drainage plan shall identify and contain all of the following:

(1) The location of the development site and waterbodies (or properties) that will receive storm water runoff.

(2) The existing and proposed topography of the development site, including the alignment and boundary of the natural drainage courses, with contours having a maximum interval of one foot (using U.S.G.S. datum). The site boundaries shall be indicated on the pertinent county soils map.

(3) The development tributary area to each point of discharge from the development.

(4) Calculations for the various discharge rates.

(5) Basis of design for any facility, structure or configuration.

(6) A drawing showing all proposed storm water runoff facilities with existing and final grades.

(7) The sizes and locations of upstream and downstream culverts serving the major drainage routes flowing into and out of the development site. Any significant offsite and onsite drainage outlet restrictions other than culverts should be noted on the drainage map.

(8) An implementation plan for construction and inspection of all storm water runoff facilities necessary to the overall drainage plan, including a schedule of the estimated dates of completing construction of the storm water runoff facilities shown on the plan. An identification of the proposed inspection procedures to ensure that the storm water runoff facilities are constructed in accordance with the approved drainage plan. An estimate of the cost to construct the storm water runoff facilities.

(9) A plan to ensure the effective control of construction site storm water runoff and sediment track-out onto roadways. If permanent storm water runoff facilities are to be used during construction, then the drainage plan must include provisions to ensure full functionality following construction.

(10) Drawings, profiles and specifications for the construction of the storm water runoff facilities reasonably necessary to ensure that storm water runoff will be drained, stored or otherwise controlled in accordance with this ordinance.

(11) A maintenance agreement, in form and substance acceptable to the **Township/Municipality**, for ensuring maintenance of any privately owned storm water runoff facilities. The maintenance agreement shall include the property owner's written commitment to provide routine, emergency and long-term maintenance of the facilities and, in the event that the facilities are not maintained in accordance with the approved drainage plan, the agreement shall authorize the **Township/Municipality** to maintain any onsite storm water runoff facility as reasonably necessary, at the property owner's expense.

(12) The name of the engineering firm and the registered professional engineer that designed the drainage plan and that will inspect final construction of the storm water runoff facilities.

(13) All design information must be compatible for conversion to the county's Geographic Information System.

(14) Any other information necessary for the **Township/Municipality** to verify that the drainage plan complies with the **Township/Municipality's** design and performance standards for drains and storm water management systems.

Sec. 2.04 Storm Water Permit Review Fees.

(1) All expenses and costs incurred by the **Township/Municipality** directly associated with processing, reviewing and approving or denying a storm water permit application shall be paid (or reimbursed) to the **Township/Municipality** from the funds in a separate escrow account established by the property owner, as provided in subsection (2). The **Township/Municipality** may draw funds from a property owner's escrow account to reimburse the **Township/Municipality** for expenses incurred by the **Township/Municipality** relating to the application. Such reimbursable expenses include, but are not limited to, expenses related to the following:

(a) Services of the **Township/Municipality** Attorney directly related to the application.

(b) Services of the **Township/Municipality** Engineer directly related to the application.

(c) Services of other independent contractors working for the **Township/Municipality** which are directly related to the application.

(d) Any additional public hearings, required mailings and legal notice requirements necessitated by the application.

(2) At the time a property owner applies for a storm water permit, the property owner shall deposit with the **Township/Municipality** clerk, as an escrow deposit, an initial amount as determined by resolution of the **[legislative body]** for such matters and shall provide additional amounts as requested by the **Township/Municipality** in such increments as are specified in said resolution. Any excess funds remaining in the escrow account after the application has been fully processed, reviewed and the final **Township/Municipality** approval and acceptance of the development has occurred will be refunded to the property owner with no interest to be paid on those funds. At no time prior to the

Township/Municipality's final decision on an application shall the balance in the escrow account fall below half the required initial amount.

[recommended initial amount: $4000, recommended increment: $2000]

Sec. 2.05 Construction Site Runoff Controls

Prior to making any earth change on a development site regulated by this ordinance, the property owner shall first obtain a soil erosion permit issued in accordance with Part 91 of Act No. 451 of the Public Acts of 1994, as amended, if one is required. The property owner shall install storm water runoff facilities for the construction period. The property owner shall phase the construction activities and take other appropriate action to minimize construction site soil erosion. The property owner shall install facilities to prevent offsite sedimentation. During all construction activities on the development site, the **Township/Municipality** Engineer may inspect the development site to ensure compliance with the approved construction site runoff controls.

Sec. 2.06 Financial Guarantee

(1) The **Township/Municipality** shall not approve a storm water permit until the property owner submits to the **Township/Municipality**, in a form and amount satisfactory to the **Township/Municipality**, a letter of credit or other financial guarantee for the timely and satisfactory construction of all storm water runoff facilities and site grading in accordance with the approved drainage plan. Upon certification by a registered professional engineer that the storm water runoff facilities have been completed in accordance with the approved drainage plan including, but not limited to, the provisions contained in Section 2.03(8), the **Township/Municipality** may release the letter of credit, or other financial guarantee, subject to final **Township/Municipality** acceptance and approval.

(2) Except as provided in subsection (3), the amount of the financial guarantee shall be the amount of the estimate of storm water runoff facilities provided with the approved drainage plan (see Section 2.03(8)), unless the **Township/Municipality** determines that an alternative amount is appropriate, in which case the basis for such determination shall be provided to the property owner in writing. In determining whether an alternative amount is appropriate, the **Township/Municipality** shall consider the size and type of the development, the size and type of the onsite storm water system, and the nature of the offsite storm water runoff facilities the development will utilize.

(3) The **Township/Municipality** _____ [planner, zoning administrator, etc.] may reduce or waive the amount of the financial guarantee for a development that will not increase the percentage of impervious surface of the development site by more than ten percent (10%).

(4) This ordinance shall not be construed or interpreted as relieving a property owner of its obligation to pay all costs associated with onsite private storm water runoff facilities as well as those costs arising from the need to make other drainage improvements in order to reduce a development's impact on a drain consistent with adopted design standards.

Sec. 2.07 Certificate of Occupancy

No certificate of occupancy shall be issued until storm water runoff facilities have been completed in accordance with the approved drainage plan; provided, however, the **Township/Municipality** may issue a certificate of occupancy if an acceptable letter of credit or other financial guarantee has been submitted to the **Township/Municipality**, for the timely and satisfactory construction of all storm water runoff facilities, site grading and site stabilization in accordance with the approved drainage plan.

Sec. 2.08 No Change in Approved Facilities

Storm water runoff facilities, after construction and approval, shall be maintained in good condition, in accordance with the approved drainage plan. The facilities shall not be subsequently altered, revised or replaced except in accordance with the approved drainage plan, or in accordance with revisions to the plan that have been approved by the **Township/Municipality**.

Sec. 2.09 Terms and Conditions of Permits

In granting a storm water permit, the **Township/Municipality** shall impose such terms and conditions as are reasonably necessary to effectuate the purposes of this ordinance. A property owner shall comply with such terms and conditions.

For the purpose of this ordinance, the following terms and conditions shall be imposed by the storm water permit, unless the **Township/Municipality** specifically indicates otherwise:

(1) Permit Term – The permit shall expire and have no further force or effect within two years of issuance unless construction has begun on the development site.

(2) Construction Period – All construction shall be complete within three years of permit issuance. The **Township/Municipality** Engineer may extend the construction period upon adequate justification submitted by the property owner.

(3) Permit Termination – The property owner may unilaterally terminate the permit at any time prior to the start of construction by notice to the **Township/Municipality**. The property owner may request permit termination at any time. If construction is complete the **Township/Municipality** Engineer shall perform a final inspection of the development site. If the storm water runoff facilities are found to be constructed in accordance with the drainage plan and are in acceptable condition, the Engineer shall provide a certificate of final approval and acceptance terminating the permit. Upon termination, the clerk shall release any funds remaining in escrow to the property owner.

(4) Premature Permit Termination – The property owner may request premature permit termination if construction has begun but will not be completed. The **Township/Municipality** Engineer shall proceed to negotiate a termination settlement agreement with the property owner that properly effectuates the purposes of this ordinance and minimizes the liability of the **Township/Municipality.** Upon entering a termination settlement agreement, the clerk shall release any funds remaining in escrow to the property owner.

Article III – Storm Water System, Floodplain and Other Standards, Soil Erosion Control

Sec. 3.01 Management of and Responsibility for Storm Water System

The **Township/Municipality** is not responsible for providing drainage facilities on private property for the management of storm water on said property. It shall be the responsibility of the property owner to provide for, and maintain, private storm water runoff facilities serving the property and to prevent or correct the accumulation of debris that interferes with the drainage function of a waterbody.

Sec. 3.02 Storm Water System

All storm water runoff facilities shall be constructed and maintained in accordance with all applicable federal, state and local ordinances, and rules and regulations.

Sec. 3.03 Storm Water Discharge Rates and Volumes

The **Township/Municipality** has established minimum design standards (Article VIII) for storm water discharge release rates and to require dischargers to implement onsite retention, detention or other methods necessary to control the rate and volume of surface water runoff discharged into the storm water drainage system.

Sec. 3.04 Floodplain Standards

(1) All new buildings and substantial improvements to existing buildings shall be protected from flood damage up to the Flood Protection Elevation (FPE) and shall be in accordance with all applicable federal, state and local ordinances, and rules and regulations. Floodway alteration in watersheds less than 2 square miles shall be permitted only upon review and approval by the Township/Municipality, in accordance with an approved drainage plan. Floodplain and floodway alteration in larger watersheds is permitted only as approved by the Michigan Department of Environmental Quality.

(2) A drainage plan providing for the filling or alteration of a floodway must include provisions for maintaining stability of the banks of streams or other waterbodies, by means of the establishing of buffer zones and other means of providing protection of the slopes and banks of waterbodies.

Sec. 3.05 Soil Erosion and Sedimentation Control

(1) All persons who cause, in whole or in part, any earth change to occur that disturbs one or more acres shall provide soil erosion and sedimentation control so as to adequately prevent soils from being eroded and discharged or deposited onto adjacent properties or into a storm water drainage system, a public street or right of way, wetland, creek, stream, waterbody or floodplain. All development shall be

in accordance with all applicable federal, state and local ordinances, rules and regulations.

(2) During any earth change which exposes soil to an increased risk of erosion or sediment track-out, the property owner and other persons causing or participating in the earth change shall do the following:
   (a) Comply with the storm water management standards of this ordinance.
   (b) Obtain and comply with the terms of a soil erosion and sedimentation control permit if required by law.
   (c) Prevent damage to any public utilities or services within the limits of grading and within any routes of travel or work areas of construction equipment.
   (d) Prevent damage to or impairment of any waterbody on or near the location of the earth change.
   (e) Prevent damage to adjacent or nearby land.
   (f) Apply for all required approvals or permits prior to the commencement of work.
   (g) Proceed with the proposed work only in accordance with the approved plans and in compliance with this ordinance.
   (h) Maintain all required soil erosion and sedimentation control measures, including but not limited to, measures required for compliance with the terms of this ordinance.
   (i) Promptly remove all soil, sediment, debris or other materials applied, dumped, tracked or otherwise deposited on any lands, public streets, sidewalks or other public ways or facilities, including catch basins, storm sewers, ditches, drainage swales or waterbodies.
   (j) Refrain from grading lands at locations near public streets, sidewalks, alleys or other public or private property without providing adequate support or other measures so as to protect such other lands, streets, sidewalks or other property from settling, cracking or sustaining other damage.

Sec. 3.06 Building Openings

(1) No building opening shall be constructed below the following elevations:
   (a) One foot above the 100-year floodplain.
   (b) The building opening established at the time of plat or development approval and on file in the **Township/Municipal** Engineering Department.
   (c) Three feet above the top of any downstream culvert.
   (d) Four feet above the bottom of any permanent and defined drain.

(2) A waiver from elevations stated in Section 3.05(1) may be granted by the **Township/Municipal** Engineer following receipt of a certification from a registered professional engineer demonstrating that the proposed elevation does not pose a risk of flooding.

(3) Upon completion of construction of the structure's foundation and/or slab on grade, a registered land surveyor shall certify any minimum building opening elevation specified by this ordinance. This certificate shall attest that the building opening elevation complies with the standards of this ordinance. The permittee for the building permit shall submit the certificate to the **Township/Municipal** Building

Inspections official prior to the commencement of framing and/or structural steel placement. If the surveyor should find that the minimum building opening elevation is below the elevation specified in Section 3.06(1)(b) or (c), that opening must be raised using a method that meets with the approval of the **Township/Municipality**. After reconstruction, a registered land surveyor or engineer shall recertify that the minimum building opening elevation complies with the standards of this ordinance prior to the commencement of framing and or structural steel placement.

Sec. 3.07 Sump Pump Discharge

(1) Whenever building footing drains are required or utilized, a direct connection between the footing drains through a sump pump-check valve system to a storm sewer is required. A gravity system is not permitted.
(2) A storm water lateral shall be provided for each parcel at the time of storm sewer construction.

Sec. 3.08 Public Health, Safety and Welfare

Protection of the public health, safety and welfare shall be a primary consideration in the design of all storm water runoff facilities.

Article IV – Prohibitions and Authorizations

Sec. 4.01 Prohibited Discharges

(1) It is unlawful for any person to discharge, or cause to be discharged, to a storm water drainage system or water body any substance or material, including, but not limited to, pollutants or waters containing any pollutants that cause or contribute to a violation of applicable water quality standards, other than storm water or an authorized discharge. This prohibition includes the commencement, conducting or continuance of any illicit discharge by any person to a storm water drainage system or water body.

(2) Any person discharging storm water shall effectively prevent pollutants from being discharged with the storm water, except in accordance with BMPs.

(3) The Authorized Enforcement Agency is authorized to require dischargers to implement pollution prevention measures, using Storm Water Pollution Prevention Plans and BMPs, as determined necessary by the Authorized Enforcement Agency to prevent or reduce the discharge of pollutants to a storm water drainage system or water body.

(4) The discharge prohibitions of this section shall not apply to any non-storm water discharge authorized under an NPDES permit, waiver or waste discharge order issued to the discharger and administered under the authority of the EPA, provided the discharger is in full compliance with all requirements of the permit, waiver or order and other applicable laws and regulations, and provided that written approval has been granted for any discharge to the storm water drainage system.

Sec. 4.02 Prohibited Illicit Connections

(1) It is unlawful for any person to construct, use or maintain (or to allow the construction, use, maintenance or continued existence of) an illicit connection.

(2) This prohibition expressly includes, without limitation, illicit connections made prior to the effective date of this Ordinance, and regardless of whether the connection was permissible under law or practices applicable or prevailing at the time of connection.

Sec. 4.03 Authorized Discharges

The following non-storm water discharges are permissible, but only if they do not result in a violation of State of Michigan water quality standards and provided that they are undertaken in compliance with any applicable or required BMPs:

(1) Water supply line flushing.
(2) Landscape irrigation runoff.
(3) Diverted stream flows.
(4) Rising groundwater.
(5) Uncontaminated groundwater infiltration to storm drains.
(6) Uncontaminated pumped groundwater.

(7) Discharges from potable water sources.
(8) Foundation drains.
(9) Air conditioning condensate.
(10) Irrigation water.
(11) Springs.
(12) Water from crawl space pumps.
(13) Footing drains and basement sump pumps.
(14) Lawn watering runoff.
(15) Waters from noncommercial car washing.
(16) Flows from riparian habitats and wetlands.
(17) Residential swimming pool water and other dechlorinated swimming pool water, provided that any filter backwash water that is present is treated.
(18) Residual street wash water.
(19) Discharges or flows from emergency fire-fighting activities.
(20) Discharges specifically authorized in writing by the Authorized Enforcement Agency as being necessary to protect public health, welfare and safety or the environment.

Sec. 4.04 Interference with Natural or Artificial Drains

(1) It shall be unlawful for any person to stop, fill, dam, confine, pave, alter the course of or otherwise interfere with any natural or constructed drain, or drainageway without first submitting a drainage plan to the **Township/Municipality** and receiving approval of that plan. Any deviation from the approved plan is a violation of this ordinance. This section shall not prohibit, however, necessary emergency action so as to prevent or mitigate drainage that would be injurious to the environment, the public health, safety or welfare.
(2) No filling, blocking, fencing or above-surface vegetation planting shall take place within a floodway.
(3) For an overland flow-way:
    (a) Silt screen fences shall not be permitted below the top of the bank of a waterbody.
    (b) Chain link fences shall be permitted if the **Township/Municipality** determines that the fence will not obstruct or divert the flow of water.
    (c) If a fence is removed by the **Township/Municipality** for drain access or drain maintenance, the fence shall be replaced by the owner of the fence at the owner's expense.
    (d) No shrubs or trees shall be planted below the top of the bank of a waterbody.
(4) Shrubs, trees or other aboveground vegetation shall not be planted over the top of an underground storm sewer or over the top of the easement within which the storm sewer has been installed.

Sec. 4.05 Storage of Hazardous or Toxic Materials in Drainageway

Except as permitted by law, it shall be unlawful for any person to store or stockpile within a drainageway any hazardous or toxic materials unless adequate protection and/or containment has been provided so as to prevent any such materials from entering a storm water drainage system or waterbody.

Article V – Inspection, Monitoring, Reporting and Recordkeeping

Sec. 5.01 Inspection and Sampling

The Authorized Enforcement Agency may inspect and/or obtain samples from any discharger's premises as necessary to determine compliance with the requirements of this Ordinance. Upon request, the discharger shall allow properly identified representatives of the Authorized Enforcement Agency to enter the premises of the discharger at all hours necessary for the purposes of such inspection or investigation, including, but not limited to, smoke/dye testing, televising pipes, sampling and excavation. The Authorized Enforcement Agency shall provide the discharger reasonable advance notice of the need for such access, if possible and consistent with protection of public health and safety and the environment. The properly identified representatives may place on the discharger's premises the equipment or devices used for such sampling or inspection. Unreasonable delays in allowing access to premises is a violation of this Ordinance.

Sec. 5.02 Storm Water Monitoring Facilities

If directed in writing to do so by the Authorized Enforcement Agency, a discharger of storm water runoff from any premises used for commercial or industrial purposes shall provide and operate equipment or devices for the monitoring of storm water runoff to provide for inspection, sampling and flow measurement of each discharge to a water body or a storm water drainage system, as specified by the Authorized Enforcement Agency. The Authorized Enforcement Agency may require a discharger to provide and operate such equipment and devices if it is necessary or appropriate for the inspection, sampling and flow measurement of discharges in order to determine whether adverse effects from, or as a result of, such discharges may occur. All such equipment and devices for the inspection, sampling and flow measurement of discharges shall be installed and maintained at the discharger's expense in accordance with applicable laws, ordinances and regulations.

Sec. 5.03 Accidental Discharges

Any discharger who accidentally discharges into a storm water drainage system or a water body any substance other than storm water or an authorized discharge shall immediately notify the Authorized Enforcement Agency of the discharge. If the notification is given orally, a written report concerning the discharge shall be filed with the Authorized Enforcement Agency within five (5) days. The written report shall specify all of the following:

(1) The composition of the discharge and the cause thereof.
(2) The exact date, time and estimated volume of the discharge.
(3) All measures taken to clean up the discharge, all measures taken or proposed to be taken to mitigate any known or potential adverse impacts of the discharge, and all measures proposed to be taken to reduce and prevent any recurrences.
(4) The names and telephone numbers of the individual making the report, and (if different) the individual who may be contacted for additional information regarding the discharge.

Sec. 5.04 Record Keeping Requirement

Any person that violates any requirement of this Ordinance or that is subject to monitoring under this Ordinance shall retain and preserve for no less than three years any and all books, drawings, plans, prints, documents, memoranda, reports, correspondence and records, including records on magnetic or electronic media, and any and all summaries of such records relating to monitoring, sampling and chemical analysis of any discharge or storm water runoff from any premises connected with the violation or subject to monitoring.

Article VI – Enforcement

Sec. 6.01 Sanctions for Violation

(1) Violation; Municipal Civil Infraction. Except as provided by Section 4.01(6), and notwithstanding any other provision of the **Township/Municipality**'s laws, ordinances and regulations to the contrary, a person who violates any provision of this Ordinance (including, without limitation, any notice, order, permit, decision or determination promulgated, issued or made by the Authorized Enforcement Agency under this Ordinance) is responsible for a municipal civil infraction, subject to payment of a civil fine of not less than [$1,000] per day for each infraction and not more than [$10,000] per day for each infraction, plus costs and other sanctions.

(2) Repeat offenses; increased fines. Increased fines may be imposed for repeat offenses. As used in this section, "repeat offense" means a second (or any subsequent) municipal civil infraction violation of the same requirement or provision of this Ordinance (i) committed by a person within any 12-month period and (ii) for which the person admits responsibility or is determined to be responsible. The increased fine for a repeat offense under this Ordinance shall be as follows:

(a) The fine for any offense that is a first repeat offense shall be not less than [$2,500], plus costs.

(b) The fine for any offense that is a second repeat offense or any subsequent repeat offense shall be not less than [$5,000], plus costs.

(3) Amount of Fines. Subject to the minimum fine amounts specified in Sections 6.01(2)(a) and 6.01(2)(b), the following factors shall be considered by a court in determining the amount of a municipal civil infraction fine following the issuance of a municipal civil infraction citation for a violation of this Ordinance: the type, nature, severity, frequency, duration, preventability, potential and actual effect, and economic benefit to the violator (such as delayed or avoided costs or competitive advantage) of a violation; the violator's recalcitrance or efforts to comply; the economic impacts of the fine on the violator; and such other matters as justice may require. A violator shall bear the burden of demonstrating the presence and degree of any mitigating factors to be considered in determining the amount of a fine. However, mitigating factors shall not be considered unless it is determined that the violator has made all good faith efforts to correct and terminate all violations.

(4) Authorized Local Official. Notwithstanding any other provision of the **Township/Municipality**'s laws, ordinances and regulations to the contrary, the following persons are designated as the authorized local officials to issue municipal civil infraction citations (directing alleged violators to appear in district court) and/or notices (directing alleged violators to appear at the [city's, village's, township's]) Municipal Violations Bureau, as applicable) for violations of this Ordinance (in addition to any other persons so designated by the Authorized Enforcement Agency): the _____; the _____; [specify others as applicable], and any police officer.

(5) Other Requirements and Procedures. Except as otherwise provided by this section, the requirements and procedures for commencing municipal civil infraction actions; issuance and service of municipal civil infraction citations; determination and collection of court-ordered fines, costs and expenses; appearances and payment of fines and costs; failure to answer, appear or pay fines; disposition of fines, costs and expenses paid; and other matters regarding municipal civil infractions shall be as set forth in Act No. 236 of the Public Acts of 1961, as amended.

(6) Any person who (1) at the time of a violation knew or should have known that a pollutant or substance was discharged contrary to any provision of this Ordinance, or contrary to any notice, order, permit, decision or determination promulgated, issued or made by the Authorized Enforcement Agency under this Ordinance; or (2) intentionally makes a false statement, representation or certification in an application for, or form pertaining to a permit, or in a notice, report or record required by this Ordinance, or in any other correspondence or communication, written or oral, with the Authorized Enforcement Agency regarding matters regulated by this Ordinance; or (3) intentionally falsifies, tampers with or renders inaccurate any sampling or monitoring device or record required to be maintained by this Ordinance; or (4) commits any other act that is punishable under state law by imprisonment for more than 90 days; shall, upon conviction, be guilty of a misdemeanor punishable by a fine of $500 per violation, per day, or imprisonment for up to 90 days, or both in the discretion of the court.

(7) Any person who aids or abets another person in a violation of this Ordinance shall be subject to the sanctions provided in this section.

Sec. 6.02 Stop Work Order

Where there is work in progress that causes or constitutes in whole or in part a violation of any provision of this ordinance, the **Township/Municipality** is authorized to issue a Stop Work Order so as to prevent further or continuing violations or adverse effects. All persons to whom the stop work order is directed, or who are involved in any way with the work or matter described in the stop work order, shall fully and promptly comply therewith. The **Township/Municipality** may also undertake or cause to be undertaken any necessary or advisable protective measures so as to prevent violations of this ordinance or to avoid or reduce the effects of noncompliance herewith. The cost of any such protective measures shall be the responsibility of the owner of the property upon which the work is being done and the responsibility of any person carrying out or participating in the work, and such cost shall be a lien upon the property.

Sec. 6.03 Failure to Comply; Completion

The Authorized Enforcement Agency is authorized, after giving reasonable notice and opportunity for compliance, to correct any violation of this Ordinance or damage or impairment to the storm water drainage system caused by a discharge and to bill the person causing the violation or discharge for the costs of the work to be reimbursed. The costs reimbursable under this section shall be in addition to fees, amounts or other costs and expenses required to be paid to the Authorized Enforcement Agency under other sections of this Ordinance.

Sec. 6.04 Emergency Measures

If emergency measures are necessary to respond to a nuisance; to protect public safety, health and welfare; and/or to prevent loss of life, injury or damage to property, the Authorized Enforcement Agency is authorized to carry out or arrange for all such emergency measures. Property owners shall be responsible for the cost of such measures made necessary as a result of a violation of this Ordinance, and shall promptly reimburse the **Township/Municipality** for all of such costs.

Sec. 6.05 Cost Recovery for Damage to Storm Drain System

Any person who discharges to a storm water drainage system or a water body, including, but not limited to, any person who causes or creates a discharge that violates any provision of this Ordinance, produces a deposit or obstruction or otherwise damages or impairs a storm water drainage system, or causes or contributes to a violation of any federal, state or local law governing the **Township/Municipality**, shall be liable to and shall fully reimburse the **Township/Municipality** for all expenses, costs, losses or damages (direct or indirect) payable or incurred by the **Township/Municipality** as a result of any such discharge, deposit, obstruction, damage, impairment, violation, exceedance or noncompliance. The costs that must be reimbursed to the **Township/Municipality** shall include, but shall not be limited to, all of the following:

(1) All costs incurred by the **Township/Municipality** in responding to the violation or discharge, including expenses for any cleaning, repair or replacement work, and the costs of sampling, monitoring and treatment as a result of the discharge, violation, exceedance or noncompliance.

(2) All costs to the **Township/Municipality** of monitoring, surveillance and enforcement in connection with investigating, verifying and prosecuting any discharge, violation, exceedance or noncompliance.

(3) The full amount of any fines, assessments, penalties and claims, including natural resource damages levied against the **Township/Municipality**, or any **Township/Municipality** representative, by any governmental agency or third party as a result of a violation of applicable laws or regulations that is caused by or contributed to by any discharge, violation, exceedance or noncompliance.

(4) The full value of any **Township/Municipality** staff time (including any required overtime), consultant and engineering fees, and actual attorney fees and defense costs (including the **Township/Municipality** legal counsel and any special legal counsel), associated with responding to, investigating, verifying and prosecuting any discharge, violation, exceedance or noncompliance, or otherwise enforcing the requirements of this Ordinance.

Sec. 6.06 Collection of Costs; Lien

(1) Costs incurred by the **Township/Municipality** pursuant to Sections 4.02, 4.03, 4.04, and 4.06(1) shall constitute a lien on the premises, which shall be enforceable in accordance with Act No. 94 of the Public Acts of 1933, as amended from time to time, or as otherwise authorized by law. Any such charges that are delinquent for six (6) months or more may be certified annually to the **Township/Municipality** Treasurer, who shall enter the lien on the next tax roll against the premises, the costs shall be collected, and the lien shall be enforced in the same manner as provided for in the collection of taxes assessed upon the roll and the enforcement of a lien for taxes. In addition to any other lawful enforcement methods, the **Township/Municipality** shall have all remedies authorized by Act No. 94 of the Public Acts of 1933, as amended, and by other applicable laws.

(2) The failure by any person to pay any amounts required to be reimbursed to the **Township/Municipality** as provided by this Ordinance shall constitute an additional violation of this Ordinance.

Sec. 6.07 Suspension of Access to the Storm Water Drainage System

(1) Suspension due to illicit discharges in emergency situations. The Authorized Enforcement Agency may, without prior notice, suspend access to the storm water drainage system to any person or premises when such suspension is necessary to stop an actual or threatened discharge that presents or may present imminent and substantial danger to the environment, or to the health or welfare of persons, or to the storm water drainage system or a water body. If the person fails to comply with a suspension order issued in an emergency, the Authorized Enforcement Agency may take such steps as deemed necessary to prevent or minimize damage to the storm water drainage system or the environment, or to minimize danger to persons, and bill the person for the costs to the **Township/Municipality** in taking such steps.

(2) Suspension due to the detection of illicit discharge. Any person discharging to the storm water drainage system in violation of this Ordinance may have their access to the system terminated, if the Authorized Enforcement Agency determines that such termination would abate or reduce an illicit discharge. The Authorized Enforcement Agency will notify a violator of the proposed termination of its access. It shall be unlawful for any person to reinstate access of the storm water drainage system to a premises terminated pursuant to this section without the prior written approval of the Authorized Enforcement Agency.

Sec. 6.08 Appeals

Any person to whom any provision of this Ordinance has been applied may appeal in writing to **(specify local entity)**, not later than 30 days after the action or decision being appealed. Such appeal shall identify the matter being appealed, and the basis for the appeal. The **(entity)** shall consider the appeal and make a decision whereby it affirms, rejects or modifies the action being appealed. In considering any such appeal, the **(entity)** may consider the recommendations of the Authorized Enforcement Agency and the comments of other persons having knowledge or expertise regarding the matter. In considering any such appeal, the **(entity)** may grant a temporary variance from the terms of this Ordinance so as to provide relief, in whole or in part, from the action being appealed, but only upon finding that the following requirements are satisfied:

(1) The application of the Ordinance provisions being appealed will present or cause unnecessary hardship for the person appealing; provided, however, that unnecessary hardship shall not include the need for a property owner to incur additional reasonable expenses in order to comply with the Ordinance; and

(2) The granting of the relief requested will not prevent accomplishment of the goals and purposes of this Ordinance, nor result in less effective management of storm water runoff.

Sec. 6.09 Judicial Relief

With the approval of the **Township/Municipality**, the Authorized Enforcement Agency may institute legal proceedings in a court of competent jurisdiction to seek all appropriate relief for violations of this Ordinance or of any permit, order, notice or agreement issued or entered into under this Ordinance. The action may seek temporary or permanent injunctive relief, damages, penalties, costs and any other relief, at law or equity, that a court may order. The Authorized Enforcement Agency may also seek collection of fines, penalties and any other amounts due to the **Township/Municipality** that a person has not paid.

Sec. 6.10 Cumulative Remedies

The imposition of a single penalty, fine, order, damage or surcharge upon any person for a violation of this Ordinance, or of any permit, order, notice or agreement issued, or entered into under this Ordinance, shall not preclude the imposition by the **Township/Municipality**, the Authorized Enforcement Agency, or a court of competent jurisdiction of a combination of any or all of those sanctions and remedies or additional sanctions and remedies with respect to the same violation, consistent with applicable limitations on penalty amounts under state or federal laws or regulations. A criminal citation and prosecution of a criminal action against a person shall not be dependent upon and need not be held in abeyance during any civil, judicial or administrative proceeding, conference or hearing regarding the person.

Article VII – Storm Water Easements and Maintenance Agreements

Sec. 7.01 Applicability of Requirements

The requirements of this Article concerning storm water easements and maintenance agreements shall apply to all persons required to submit a drainage plan to the **Township/Municipality** for review and approval.

Sec. 7.02 Storm Water Management Easements

The property owner shall provide all storm water management easements necessary to implement the approved drainage plan and to otherwise comply with this ordinance in form and substance required by the **Township/Municipality** and shall record such easements as directed by the **Township/Municipality**. The easements shall ensure access for proper inspection and maintenance of storm water runoff facilities and shall provide adequate emergency overland flow-ways.

Sec. 7.03 Maintenance Agreements

The property owner shall provide all storm water maintenance agreements necessary to implement the approved drainage plan and to otherwise comply with this ordinance in form and substance as required by the **Township/Municipality**, and shall record such agreements as directed by the **Township/Municipality**. The maintenance agreements shall, among other matters, ensure access for proper inspection and maintenance of storm water runoff facilities and adequate emergency overland flow-ways.

Sec. 7.04 Establishment of County Drains

Prior to final approval, all storm water management facilities for platted subdivisions shall be established as county drains, as authorized in Section 433, Chapter 18 of the Michigan Drain Code (P.A. 40 of 1956, as amended) for long-term maintenance.

Article VIII – Performance and Design Standards

Sec. 8.01 Responsibility to Implement BMPs

The owner or operator of a premises used for commercial or industrial purposes shall provide, at the owner or operator's own expense, reasonable protection from an accidental discharge of prohibited materials or other wastes into the storm water drainage system or water body through the use of structural and nonstructural BMPs. Further, any person responsible for a premises that is, or may be, the source of an illicit discharge may be required to implement, at the person's expense, additional structural and nonstructural BMPs to prevent the further discharge of pollutants to the storm water drainage system or water body. Compliance with all terms and conditions of a valid NPDES permit authorizing the discharge of storm water associated with industrial activity, to the extent practicable, shall be deemed compliance with the provisions of this section.

Sec. 8.02 Performance Standards

(1) Adequate Outlet – Except as provided in Sec. 2.02(3)(b) storm water management systems shall include an adequate storm water outlet. At a minimum, a storm water outlet shall be deemed inadequate if it exceeds its reasonable share of the maximum capacity of the downstream watercourse or conduit.

(2) Flood Control – The peak flow rate of runoff leaving the development site shall be limited to prevent an increase in the frequency and magnitude of out-of-bank flooding generated by development. Designing a storm water management system to meet these minimum performance standards shall be the responsibility of the property owner.

(3) Stream Protection – The runoff produced by the 1.5-year storm event shall be captured in a detention basin, or an alternative facility as a component of a storm water management system, and shall be released such that the centroid of the discharge hydrograph is 24 hours later than the centroid of the influent hydrograph.

(4) Water Quality - The first flush shall be treated to effectively remove suspended – sediment. Additionally, sheet flow from adjacent surfaces shall be prevented from entering a watercourse, or shall be treated by vegetated buffer strips or other means of slowing runoff velocities to allow sediment and other pollutants to settle.

(5) Natural Drainage Pattern – To the fullest extent possible, storm water management systems shall follow the natural drainage pattern of the land within the development site and within the watershed in which the site is located. The natural drainage pattern includes both surface runoff paths and infiltration of precipitation. Infiltration may be required where important to preserve groundwater or wetland water elevations.

(6) Groundwater Recharge – The **Township/Municipality** may require that storm water be infiltrated to the groundwater to avoid an increase in runoff volume or in situations where important natural resources depend on certain groundwater levels, such as a perennial stream or a wetland.

(7) Low Impact Development – Low Impact Development techniques are encouraged to reduce the runoff volume and rate. This is accomplished through impervious area reduction, infiltration, interception and reuse. The reduction of runoff volume may result in a reduced size of detention facilities.

(8) Spill Protection – The **Township/Municipality** may require that storm water be contained or treated in areas that have a high potential for storm water contacting polluting materials.

Sec. 8.03 Design Standards

The Performance Standards, as described in Section 8.02 (3), (4) and (5), may be accomplished by the following Design Standards for storm water runoff facilities. Alternatives are described for certain situations. The property owner may propose alternative facilities to accomplish the Performance Standards, subject to **Township/Municipality** approval.

(1) Flood Control – The storm water runoff facilities shall detain the storm water generated by the 100-year storm and control the release to a waterbody or storm drain to a rate of less than 0.15 cfs/acre of development site.
   (a) Direct discharges to Anchor Bay or the St. Clair River need not meet this requirement.
   (b) If the property owner demonstrates that meeting this requirement will have a negative effect on downstream properties, the amount of detention and release rate may be adjusted with **Township/Municipality** approval.
   (c) If the property owner demonstrates that the development will not generate an increase in the frequency and magnitude of out-of-bank flooding as a result of the mitigating effects of a lake, pond or wetland receiving the discharge, and if the impacts to the lake, pond or wetland are acceptable, then this requirement need not be met. The demonstration would need to assume that all other properties tributary to the lake, pond or wetland would have similar storm water management controls.
   (d) For Crapau Creek, the release rate shall be limited to 0.1 cfs/acre.

(2) Stream Protection –
   (a) The storm water runoff facilities shall provide a minimum volume determined on the basis of the following equation.

$$V = 5960\left(\frac{CN}{100}\right)^{5.42}$$

Where V is the volume of the detention basin needed for stream protection in cubic feet per acre of development site tributary to the detention basin.

CN is the site average runoff Curve Number as determined by the following table.

Runoff Curve Numbers (Soil Conservation Service, *Urban Hydrology for Small Watersheds*, Technical Release No. 55, U.S. Dept. of Agriculture, Washington, D.C., January, 1975.)

Description of Land Use	Hydrologic Soil Group			
	A	B	C	D
Paved Parking Lots, Roofs, Driveways	98	98	98	98
Streets and Roads:				
Paved with curbs and storm sewers	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89
Cultivated (Agricultural Crop) Land*:				
Without conservation treatment (no terraces)	72	81	88	91
With conservation treatment (terraces, contours)	62	71	78	81
Pasture or Range Land:				
Poor (<50% ground cover or heavily grazed)	68	79	86	89
Good (50-75% ground cover; not heavily grazed)	39	61	74	80
Meadow (grass, no grazing, mowed for hay)	30	58	71	78
Brush (good, >75% ground cover)	30	48	65	73
Woods and Forests:				
Poor (small trees/brush destroyed by over-grazing or burning)	45	66	77	83
Fair (grazing but not burned; some brush)	36	60	73	79
Good (no grazing; brush covers ground)	30	55	70	77
Open Spaces (lawns, parks, golf courses, cemeteries, etc.):				
Fair (grass covers 50-75% of area)	49	69	79	84
Good (grass covers >75% of area)	39	61	74	80
Commercial and Business Districts (85% impervious)	89	92	94	95
Industrial Districts (72% impervious)	81	88	91	93
Residential Areas:				
1/8 Acre lots, about 65% impervious	77	85	90	92
1/4 Acre lots, about 38% impervious	61	75	83	87
1/2 Acre lots, about 25% impervious	54	70	80	85
1 Acre lots, about 20% impervious	51	68	79	84

or by

$$V = 5340\ cft / impervious\ acre\ (DCIA)$$

(b) The storm water runoff facilities shall provide an outlet control structure capable of limiting the discharge rate in accordance with the following equation.

$$Q = 0.052\left(\frac{CN}{100}\right)^{5.47}$$

Where Q is the peak release rate of the detention basin needed for stream protection in cubic feet per second per acre of development site tributary to the detention basin.

CN is the site average runoff Curve Number as determined by the above table.

or by

$$Q = 0.05\ cfs / impervious\ acre\ (DCIA)$$

(c) Direct discharges to Anchor Bay or the St. Clair River need not meet this requirement.

(d) If the property owner demonstrates that the development will not generate an increase in streambank erosion as a result of the mitigating effects of a lake, pond or wetland receiving the discharge, and if the impacts to the lake, pond or wetland are acceptable, then this requirement need not be met. The demonstration would need to assume that all other properties tributary to the lake, pond or wetland would have similar storm water management controls.

(3) Water Quality – The storm water runoff facilities shall treat the runoff from the first one-half inch of rainfall on the site. The treatment shall be provided by any of the following:

(a) Permanent pool as a part of a wet detention basin. Pool volume must be 2.5 times greater than the volume of runoff from the first one-half inch of rain.

(b) Extended detention volume determined by release of the runoff from the first one-half inch of rain over at least 24 hours.

(c) Retention or infiltration systems.

(d) Sand filtration or equivalent.

Sec. 8.04 Resolution to Implement Performance and Design Standards

The **[legislative body]** of the **Township/Municipality** may adopt a resolution establishing more detailed design and performance standards for storm water runoff facilities, consistent with the terms of this ordinance, and in order to further implement its goals and purposes.

Article IX – Other Matters

Sec. 9.01 Interpretation

Words and phrases in this ordinance shall be construed according to their common and accepted meanings, except that words and phrases defined in Section 1.05 shall be construed according to the respective definitions given in that section. Technical words and technical phrases that are not defined in this ordinance but which have acquired particular meanings in law or in technical usage shall be construed according to such meanings.

Sec. 9.02 Catch-Line Headings

The catch-line headings of the articles and sections of this ordinance are intended for convenience only, and shall not be construed as affecting the meaning or interpretation of the text of the articles or sections to which they may refer.

Sec. 9.03 Severability

The provisions of this ordinance are hereby declared to be severable, and if any part or provision of this ordinance should be declared invalid or unenforceable by any court of competent jurisdiction, such invalidity or unenforceability shall not affect any other part or provision of the ordinance.

Sec. 9.04 Other Ordinances

This ordinance shall be in addition to other ordinances of the **Township/Municipality**, and shall not be deemed to repeal or replace other ordinances or parts thereof except to the extent that such repeal is specifically provided for in this Article.

Sec. 9.05 Effective Date

This ordinance shall become effective _____, following its publication or following the publication of a summary of its provisions in a local newspaper of general circulation.

Sec. 9.06 Repeal [if applicable]

Ordinance No. ___, titled _____, is hereby repealed, as of the effective date of this ordinance.

This ordinance was adopted _____, by the **[Township Board, City Council or City Commission, Village Council]** and made effective _____.

_____ **Township/Municipality** Clerk